

Abronia umbellata var. *breviflora* on the Oregon coast: Reintroduction and population monitoring



2014

Report to the Bureau of Land Management, US Fish and Wildlife Service, USDA Forest Service, and Oregon Department of Parks and Recreation

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PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.



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Cover photograph: Pink sand verbena (*Abronia umbellata* var. *breviflora*).

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EXECUTIVE SUMMARY

Pink sand-verbena (*Abronia umbellata* var. *breviflora*) is listed by the Oregon Department of Agriculture as endangered, and a Species of Concern by the U.S. Fish and Wildlife Service. Since the late 1970's, the number of natural populations in Oregon has dwindled from around ten down to about five. The primary threats to the species include competition from European beachgrass (*Ammophila arenaria*) and habitat disturbance by off road vehicles.

This report summarizes pink sand-verbena research along the Oregon coast since 1997, including seeding and transplantation experiments and population monitoring at several beach and dune habitats. In 2012-2014 plant measurements were taken on randomly selected plants at select Forest Service and BLM sites. Substrate samples were collected at each site monitored in 2012.

In **2014**, our actions and observations included:

1. USDA Forest Service, Siuslaw National Forest sites
 - a. Tahkenitch: 40,00 seeds were distributed at Tahkenitch in 2014, resulting in a total of 110 plants (43 reproductive). This was the fourth seeding at the site since 2005. In 2014 seeding was focused in the southern 1/3 of the site as this was the area that had been most successful in previous years.
 - b. Siltcoos Creek: 10,000 seeds were distributed in the portion of habitat still present at the site and 10 plants (8 reproductive) were found in the fall of 2014. Although a large portion of the occupied habitat was washed away in winter storms of 2011/12, the area still hosts a relatively high density of plants per unit area and should continue to receive seeds in the remaining suitable habitat. Continued seeding efforts to establish a seedbank at the site will be crucial for the maintenance of this population.
 - c. Overlook: Despite significant decreases in this population in 2014, this population is now the second largest in Oregon and we strongly recommend continued beachgrass control and seed addition. In 2013 and 2014, both North and South Overlook had some of the lowest numbers of individuals since augmentation (introduction) began at the site.
 - i. North: 60,000 seeds were distributed, resulting in 281 plants (149 reproductive)
 - ii. South: 60,000 seeds were distributed resulting in 109 plants (66 reproductive).
2. USDI Bureau of Land Management, Coos Bay District sites
 - a. New River: In 2014, 100,000 seeds were distributed by BLM staff, resulting in 366 plants (160 reproductive). This represents a significant increase from previous

years. As in 2012 and 2013, most plants were found in areas where breaks in the foredune had allowed overwash to occur-- highlighting the affinity of pink sand-verbena for areas with repeated disturbance (and possibly nutrient input). Continued seeding at the site should augment the existing seed bank; management in the form of continued European beachgrass control will be vital in maintaining suitable habitat for this and other dune species.

- b. Coos Bay North Spit: 100,000 seeds were distributed by BLM staff. Monitoring of the area was divided into three sub-sections and the entire population was subsampled. In 2013, there was only an estimated 74,805 plants down from more than 300,000 in 2012. This is in large part due to decreases in the density of plants in the southern portion of the habitat that did not receive beachgrass removal treatment. In 2014, after beachgrass removal resumed, the population increased, with over 400,000 estimated plants. This highlights the precarious position of this species which is reliant on continued management actions to maintain suitable habitat.

We observed that 2014 was generally a poor year for *Abronia umbellata* ssp. *breviflora* across the coast: many sites monitored had fewer plants than previous years, (and in most cases were among the lowest ever observed), plant measurements of reproductive individuals also generally show smaller plants with fewer flowers/infructescences. Only Tahkenitch, New River and the Coos Bay North Spit showed increases in plants from 2013.

As in previous years, competition from European beachgrass continues to be a major factor in the success of pink sand-verbena populations. This was particularly evident at Overlook, Tahkenitch, and the Coos Bay North Spit where in 2013 the boundary between the disced and un-disced area also clearly marked a significant decrease in the number and vigor of flowering individuals.

The population of pink sand verbena on the Coos Bay North Spit- is the largest known population in Oregon and currently the only large enough to provide significant quantities of seed for restoration of the species. Continued management of the population is key to the success of this disturbance loving species. Additionally, in recent years, there appear to be unidentified factors (potentially including soil chemistry or microclimate variations) that are contributing to yearly fluctuations in population size.

Siltcoos:

Natural disturbance at the site has resulted in the erosion of more than 80% of the area occupied by ABUM in the 2010-11 growing season. This process illustrates the transitory nature of the species' preferred habitat which includes dunes particularly along the ever shifting and (sediment) nutrient dense mouths of Northwest streams. Despite the significant loss of habitat several plants were present in 2014 and continued seeding is recommended for the site to maintain a seedbank as the habitat re-establishes.

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Abronia umbellata var. *breviflora* on the Oregon coast: Reintroduction and population monitoring

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Abronia umbellata var. *breviflora* on the Oregon coast: Reintroduction and population monitoring

REPORT TO THE BUREAU OF LAND MANAGEMENT AND USDA FOREST SERVICE

INTRODUCTION

Pink sand-verbena (*Abronia umbellata* var. *breviflora*; Figure 1) is listed by the Oregon Department of Agriculture as endangered, and it is considered a Species of Concern by the U.S. Fish and Wildlife Service. Historically, the species was known from beaches along the Pacific Coast from Vancouver Island (British Columbia) south to northern California. Until two plants were discovered in Willapa Bay in 2006, the species had been believed to be extinct in Washington. In 2000, a small population (two plants) was rediscovered on Vancouver Island, but this population did not re-establish in subsequent years. Since the late 1970's, the number of natural populations in Oregon has dwindled from around ten down to about five (Figure 2). The primary threats to the species include competition from non-native species including European beachgrass (*Ammophila arenaria*) and to a lesser extent European searocket (*Cakile maritima*), American searocket (*Cakile edentula*), as well as habitat disturbance by off road vehicles and the unknown effects of climate change.

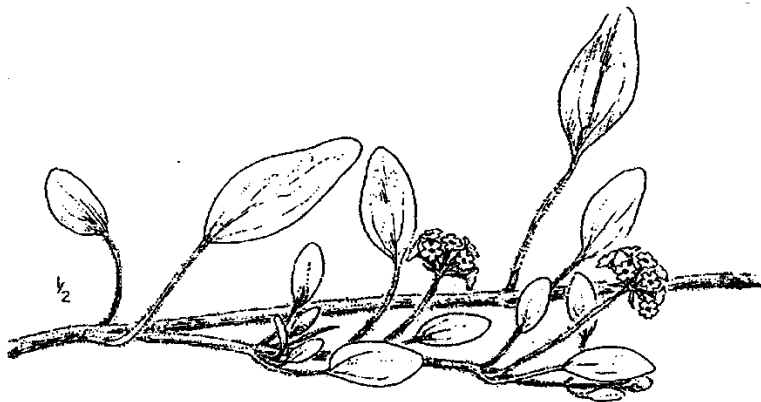


FIGURE 1. PINK SAND-VERBENA (*ABRONIA UMBELLATA* VAR. *BREVIFLORA*; FROM HITCHCOCK ET AL 1964)

The decline of pink sand-verbena along the coast is correlated with the reduction in number of many beach species, including native plants and wildlife. For example, the Western Snowy Plover has suffered a well-documented decline (Oregon Department of Fish and Wildlife 1994) that parallels that of pink sand-verbena. There is some historical evidence that snowy plovers used native vegetation, specifically sand-verbenas, for foraging and cover (Gabrielson and Jewett 1970, p.238). Recovery efforts for a variety of these dune species may be most effective if coordinated or combined.

Since the mid-1990's, research has been conducted on methods for reintroduction of pink sand-verbena. Information is still needed on the reintroduction potential of the species in various beach habitats, and an understanding of 'successful' introduction or augmentation sites developed in order to develop a range-wide conservation and recovery plan. The ultimate goal of this reintroduction effort is to support the requirements of a Conservation Strategy (Kaye 2006) and remove the species from the endangered list.

In this report, we summarize recent seeding and monitoring efforts at several beaches and dune habitats along the Oregon coast managed by the US Forest Service and BLM. This report focuses on recent efforts at the Forest Service sites: Tahkenitch Creek, Siltcoos Creek, North and South Overlook); and the Coos Bay District Bureau of Land Management sites, Coos Bay North Spit and New River. Information on additional populations, previous seeding and transplanting efforts at various sites can be found in Appendix III and in previous years' reports.

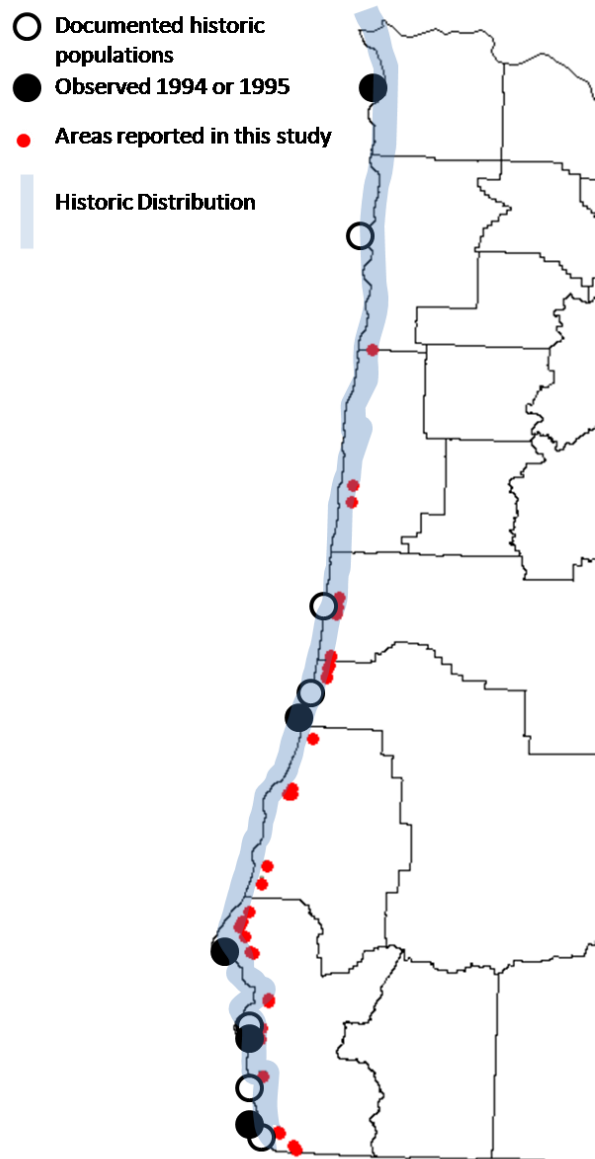


FIGURE 2. HISTORIC AND CURRENT DISTRIBUTION OF PINK SAND-VERBENA (*ABRONIA UMBELLATA* VAR. *BREVIFLORA*) IN OREGON.

SEEDING AND MONITORING OVERVIEW

General seeding and monitoring information is reviewed here. Site-specific information is included with the results of each site, below.

Seed source

All of the seed materials manually dispersed to sites in Oregon in 1997 through 2013 were collected from populations at Port Orford (1995-1997) or Coos Bay, Oregon (1999-2013). The pink sand-verbena population at Coos Bay was established from seeds originally collected at Port Orford and are therefore of the same genetic lineage (McGlaughlin et al., 2002). Due to the decline in population size at Port Orford, in 1999 we began collecting seeds at the introduced site at Coos Bay North Spit. Seeds have been collected annually with the exception of 2008 when seed collection was not possible as the Coos Bay North Spit was bulldozed and disced in mid-October prior to fruit set for most individuals. These seeds were also the source for transplants grown in greenhouses at Oregon State University and IAE in Corvallis, Oregon. We use screens to sieve mature fruits from the sand. Fruits are collected from at least 20 areas distributed throughout the population. Immature seeds and areas where non-native species are present are avoided. In 2012 and 2013 seed was collected by BLM staff at the North Spit. In 2014 BLM and IAE staff collected seed. In 2014 seed cleaning included the removal of seeds of weedy species including *Hypochaeris radicata* and *Cakile* spp.

The seeds of pink sand-verbena occur in single-seeded fruits. After collection, fruits were cleaned of residual sand and other foreign material (such as twigs and leaves) and dried. In 1999, groups of 100 fruits were weighed to determine average fruit weight, and groups of 10 fruits were clipped open to determine average seed set. In subsequent years, this information was used to weigh out bags of 10,000 seeds (154 g) each for dispersal to beaches.

Direct seeding

More than 15 sites have been seeded since this project began in 1997 (for information about sites not listed in Table 1, see “Experimental Reintroduction of Pink Sand-Verbena on the Oregon Coast: Transplanting and Seeding”, 2005). Seeded sites were revisited the following late summer/early fall to survey for pink sand-verbena plants.

Pink sand-verbena fruits were scattered in February through early April of each year by hand by walking along the beach and slowly releasing handfuls of material until all were dispersed at a rate of approximately 50 fruits per linear meter of beach.

Population surveys

General protocol - Beginning in 2000 we started surveying known pink sand-verbena habitat. Sites were selected based on population and reintroduction history and time limitations. When populations were found, we documented the number of reproductive and vegetative individuals and, occasionally, measurements of plant size (length of the longest stem, longest width, and perpendicular width). In large populations we only counted reproductive plants. Because pink sand-verbena is an annual, vegetative plants do not contribute to future populations. In 2009, due to the increase in the population size at the

Coos Bay North Spit, sampling was modified so that a sub-sample of the habitable area is sub-sampled and the population size estimated; these methods are discussed in more detail below.

Plant Measurements

In 2012-2014, additional plant measurements were recorded on selected sand-verbena plants on the North Spit . At Coos Bay North Spit, 3 (1) plant(s) were randomly selected along each survey transect. Plant measurements included length of longest branch and number of infructescences on the entire plant, the number and species of plants within 0.5m. Notes about substrate and habitat were recorded.

In 2012 and 2013, At the remaining sites, 20 points were randomly selected using GIS and uploaded points to handheld GPS units. In the field, the closest flowering plant to the preselected GPS point was monitored. Additionally, at Overlook North and South, Tahkenitch, and Siltcoos, plant characteristics were measured on a handful of overwintering plants. These plants were noted at the time of seeding in 2012 and when present monitored again in 2013 based on GPS coordinates and location information recorded.

Substrate Assessment

At all sites monitored in 2012, at least three substrate samples were collected for analysis. At this time only the pH of each sample has been determined. In the future, these samples can be analyzed for sediment size, sorting and composition to help us to determine characteristics that may be common among successful pink sand-verbena sites.

TABLE 1. REINTRODUCTION SITES FOR THE COOS BAY DISTRICT BLM, METHODS USED, AND HABITATS FOR SEEDING AND TRANSPLANTING EFFORTS DISCUSSED IN THIS REPORT. SEEDINGS REPORTED HERE ALL INVOLVED THE USE OF 50,000 SEEDS PER SITE, EXCEPT WHERE NOTED.

| Land Manager | Site | Location | Method | Habitat |
|--|----------------------|--|--|---|
| <i>Coos Bay District Bureau of Land Management</i> | | | | |
| | Coos Bay, North Spit | North of Coos Bay | <u>Seeding:</u> Dec. '96, March '06 (100k; newly restored area), March '07 (100k), March '08 (90k), Feb '09 (90k), Feb '10 (100k), Feb '11 (100k), Feb '12 (100k), Mar '13 (100k), Mar '14 (100k) | Open beach and beachgrass treatment area (sand spit) |
| | New River ACEC | sand spit near the mouth of Fourmile Creek about 8 miles south of Bandon | <u>Seeding:</u> Jan. '97, March '99, '00, '01 (70k), '02 (100k), March '03 (80k), March '04 (100k), March '05 (95k), March '06 (100k), March '07 (150k), March '08 (80k), Feb. '09, (80k) Feb. '10 (100k), Feb '11 (100k), Feb '12 (120k)*, Mar '13 (120k), Mar '14 (100k) | Foredune beachgrass treatment area and open sand * In 2012, 20k seeds were distributed in an area ~1.5 miles to the south near Butte Creek. It is recommended that additional beach grass removal occur at the site prior to any future seeding efforts. |

TABLE 2. REINTRODUCTION SITES OF THE SIUSLAW NATIONAL FOREST, METHODS USED, AND HABITATS FOR SEEDING AND TRANSPLANTING EFFORTS DISCUSSED IN THIS REPORT. SEEDINGS REPORTED HERE ALL INVOLVED THE USE OF 50,000 SEEDS PER SITE, EXCEPT WHERE NOTED.

| Land Manager | Site | Location | Method | Habitat |
|--------------------------------|--------------------|---|--|---|
| <i>Siuslaw National Forest</i> | | | | |
| | Overlook (N and S) | Douglas County about 2.5 miles south of the Lane/Douglas County line (in T20S R12W Sec 17 NW) | <u>Transplanting:</u> '00 <u>Seeding:</u> March '01 (N 50k and S 50k), March '02 (S only), March '05 (S only), March '07 (N 80k and S 50k), March '08 (N 100k), March '09 (N 50k and S 50k), March '10 (N 50k and S 50k), March '11 (N 60k and S 60k), March '12 (N 60k and S 60k), March '13 (N 60k and S 60k), March '14 (N 60k and S 60k) | Foredune beachgrass treatment area and open sand |
| | Siltcoos Creek | 10 miles north of Reedsport | <u>Transplanting:</u> '97 and '01 <u>Seeding:</u> Feb. '98, March '00, March '02 (60K), March '04, March '05, March '06, March '07 (15k to small beach north of creek and 85k to large plover area), March '08 (60k), March '09 (55k), March '10, March '11, March '12 (12.5k), Mar '13 (12.5k), Mar '14 (10k) | Foredune beachgrass treatment area and open beach, mouth of creek |
| | Tahkenitch Creek | 7 miles north of Reedsport | <u>Transplanting:</u> '97-98, '00-01 <u>Seeding:</u> Feb. '98, March '01, March '02, March '04, March '05, March '11 (80k), March '12 (100k), Mar '13 (100k), Mar '13 (40k in southern portion) | Foredune beachgrass treatment area and open beach, mouth of creek |

General Trend

The population of pink sand-verbena at every site monitored in 2013 declined from those recorded in 2012, and in 2014 populations numbers remained low. All three of the four sites managed by the Siuslaw National Forest experienced declines in both the numbers of plants. In addition, the loss of suitable habitat due to erosion at Siltcoos further reduces the area occupied by this species.

The Coos Bay North Spit (HRA) and New River (ACEC) managed by the Coos Bay District BLM both showed increases in number of plants from 2013, however 2013 had some of the lowest population numbers for these sites. 2014 also showed decreases in size and reproductive vigor at the Coos Bay North Spit.

Population size and population response to seeding varies substantially from year to year, however the significant declines observed from 2012 to 2013, across all sites, and continued decline at many sites into 2014 is cause for alarm. Two of the largest drivers appear to be amount of disturbance (e.g. the exposed beach at New River) and competition by European beach-grass. At the North Spit, there was a clear difference in the density, size and reproductive effort between plants in areas that had (or had not) received discing (and beach grass removal) treatments in 2013. Climate is also likely an important driver. On a local scale, coastal climate may also be influenced by landscape features such as headlands and nearshore rocks, which may result in differences in wave action between sites in the same year.

For a summary of inventories for pink sand-verbena conducted from 2000-2014 on the central and southern Oregon Coast see Appendix III. Some notable findings from the 2012 field season include the presence of plants at Floras Lake (State Park), which had not been seeded since 2000, as well as the presence of reproductive plants to the north of Elk River (private land managed by USFWS). There are no historic records of plants north of Elk River, so these plants are likely the result of recruitment from reproductive individuals at the nearby introduction site of Elk River, private land managed by the USFWS, or stray seeds from our seeding efforts at the site from 2009-2012.

Restoration at Siuslaw National Forest sites

Active restoration sites managed by the Siuslaw National Forest in 2014 include Siltcoos, Tahkenitch and Overlook, for information about other sites managed by the Siuslaw National Forest see the 2012 monitoring report.

Siltcoos Creek

Pink sand-verbena restoration and reintroduction was initiated at the mouth of Siltcoos Creek in 1997 when 27 plants were outplanted at the site. The population has fluctuated dramatically over time, from zero in 1999, to 989 (nearly all of which were reproductive) in 2005 (Figure 3, Table 10). In 2012, we counted 605 plants (135 reproductive and 470 vegetative), up from 415 in 2011. In the winter of 2012/2013 a substantial portion of the previously occupied habitat eroded leaving less than 20% of the original habitat. In 2014, only ten plants were noted. Despite the loss of habitat in 2012, Siltcoos has consistently had one of the highest reintroduction success rates, and we recommend continued seed addition efforts and beach-grass removal.

In 2011, plants at this site were generally larger and had more fruits per plant compared to the other sites we monitored.

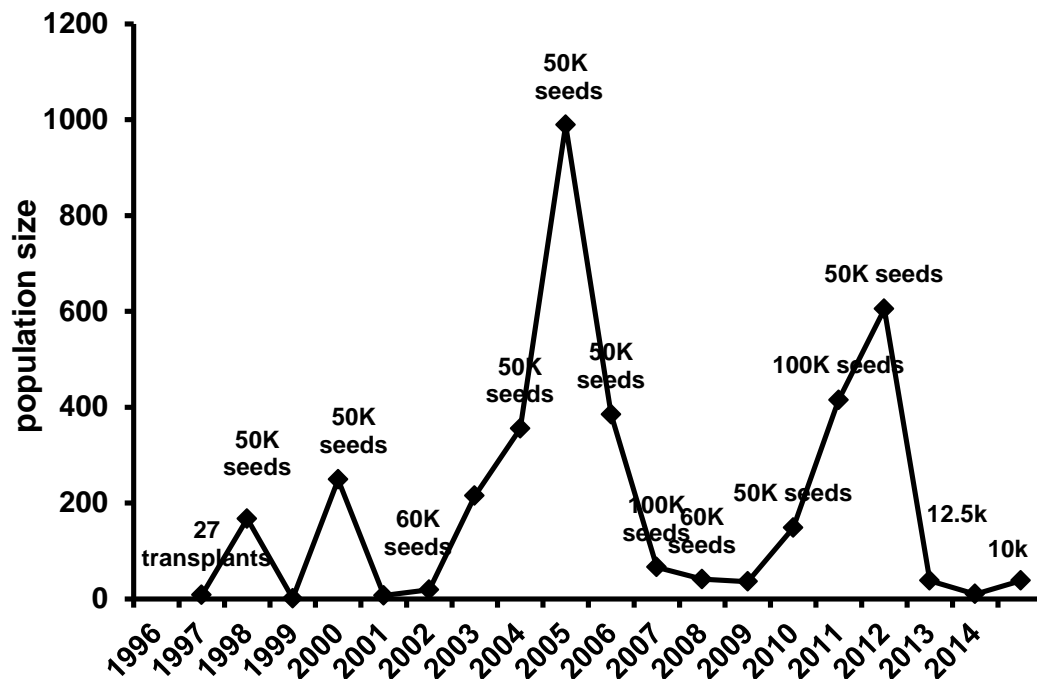


FIGURE 3. POPULATION TRENDS AND SEEDING HISTORY AT SILTCOOS CREEK, 1996 – 2014. AN EROSION EVENT IN THE WINTER OF 2012/2013 RESULTED IN SIGNIFICANT LOSS OF HABITABLE HABITAT, THUS THE DECREASE IN SEEDING EFFORT AND THE NUMBER OF PLANTS OBSERVED AT THE SITE.

Tahkenitch Creek

In 1996, 34 transplanted pink sand-verbenas and 5,000 seeds were dispersed at Tahkenitch Creek as part of an early effort to establish plants on Oregon beaches. This effort has been followed with two additional transplanting efforts and seeding. Prior to 2005, the area was divided into two sections, North Tahkenitch and South Tahkenitch. The Tahkenitch stream channel has shifted to the south and now the entire area is north of the creek. In 2005 no plants were found and in 2006 only one vegetative plant was present. An informal survey in 2009 by Marty Stein located 4 plants, 2 reproductive and 2 vegetative, suggesting that this site may be suitable for future reintroduction efforts. In 2011, 80,000 seeds were distributed resulting in 95 plants (57 vegetative and 38 reproductive). In 2012, 100,000 seeds were distributed resulting in 381 plants (246 vegetative and 135 reproductive.) Seeding continued in 2013 and 2014 resulting in 10 and 110 plants respectively. Despite the small number of plants in 2013, we recommend continued seeding in the area combined with beach grass control will help to build the seed bank at this site.

Overlook North and South

European beach-grass control was initiated at the Overlook sites in the fall of 1999 through the use of bulldozers operated by the Oregon National Guard in coordination with the Siuslaw National Forest.

Pink sand-verbena reintroduction at the Overlook sites began in spring 2000 with the planting of 50 individuals. In 2001, both the north and south sites received 50,000 seeds which resulted in the establishment of 482 and 658 plants, respectively (1,140 total).

At Overlook North from 2002-2006 no seeding occurred. Seeding resumed in 2007 and has continued annually (Table 10). Since 2008, the population has remained relatively stable. In 2012, North Overlook had 4,860 plants (3,233 vegetative and 1,627 reproductive). This is the second highest number of plants found at the site however the ratio of reproductive to vegetative plants was lower. At South Overlook seeding has occurred annually with the exceptions of 2002, 2003, and 2006. In 2012 South Overlook had 2,247 plants (1,619 vegetative and 928 reproductive). In 2013 as with other sites, the number of plants decreased to just 482 plants (395 vegetative and 87 reproductive). This pattern continued into 2014, with only 109 (66 reproductive) plants at North Overlook and 281 (149 reproductive) plants at South Overlook.

Despite the precipitous drop in the population from 2012-2014, the reintroduced population at the Overlook sites is now the second largest population in Oregon (Coos Bay North Spit is the largest). Without continual beach-grass control, the substantial population growth at this site will likely reverse and the population will decline. In 2010 at Overlook South there was an increase in the amount of *Leymus mollis* at the site, particularly at the north end and a corresponding decrease in the number of pink sand verbena at the north end. Although this species is native, it may negatively interact with pink sand verbena. We recommend that seeding continue at both sites, with higher priority given to the Overlook South treatment area with the potential addition of other native dune species (see Recommendations section). We also recommend continued observations of the spread and potential impact of *Leymus*.

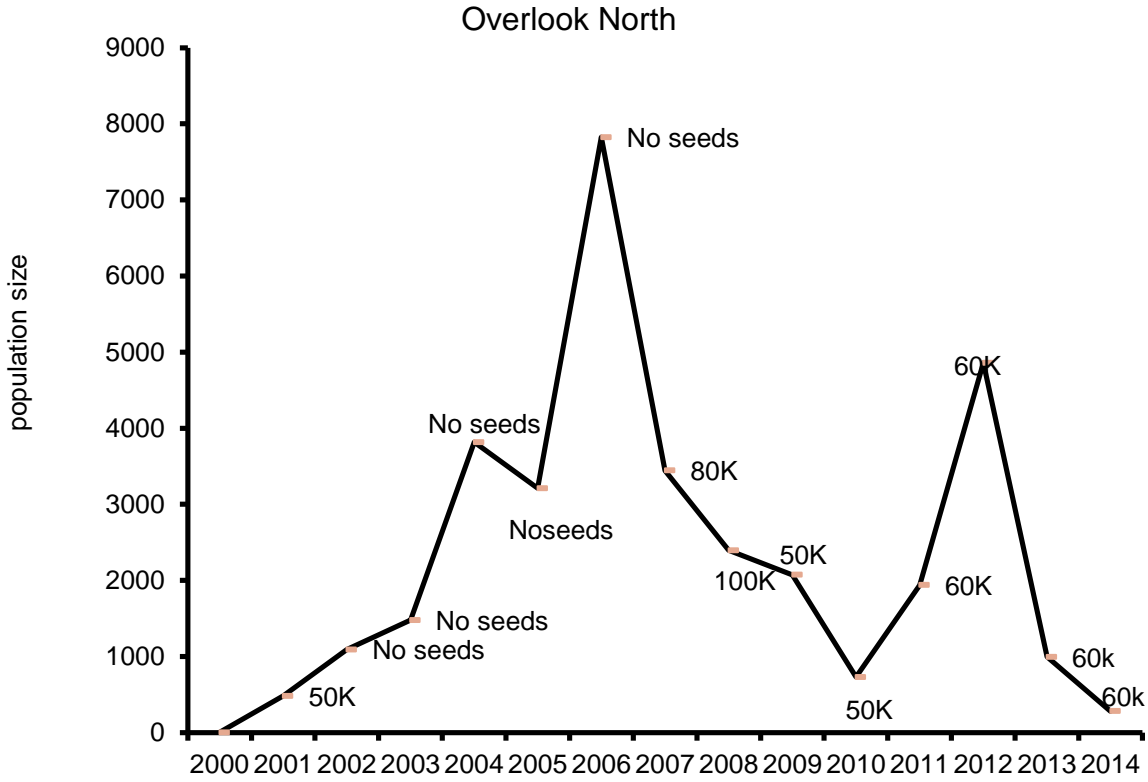


FIGURE 4. TOTAL NUMBER OF PINK SAND-VERBENA PLANTS COUNTED AT NORTH OVERLOOK SITE, 2000-2014. SEEDING AND TRANSPLANTING EVENTS ARE MARKED AT EACH APPLICABLE YEAR. SOUTH OVERLOOK WAS NOT SURVEYED IN 2008; THE DATAPOINT REFERS ONLY TO NORTH OVERLOOK.

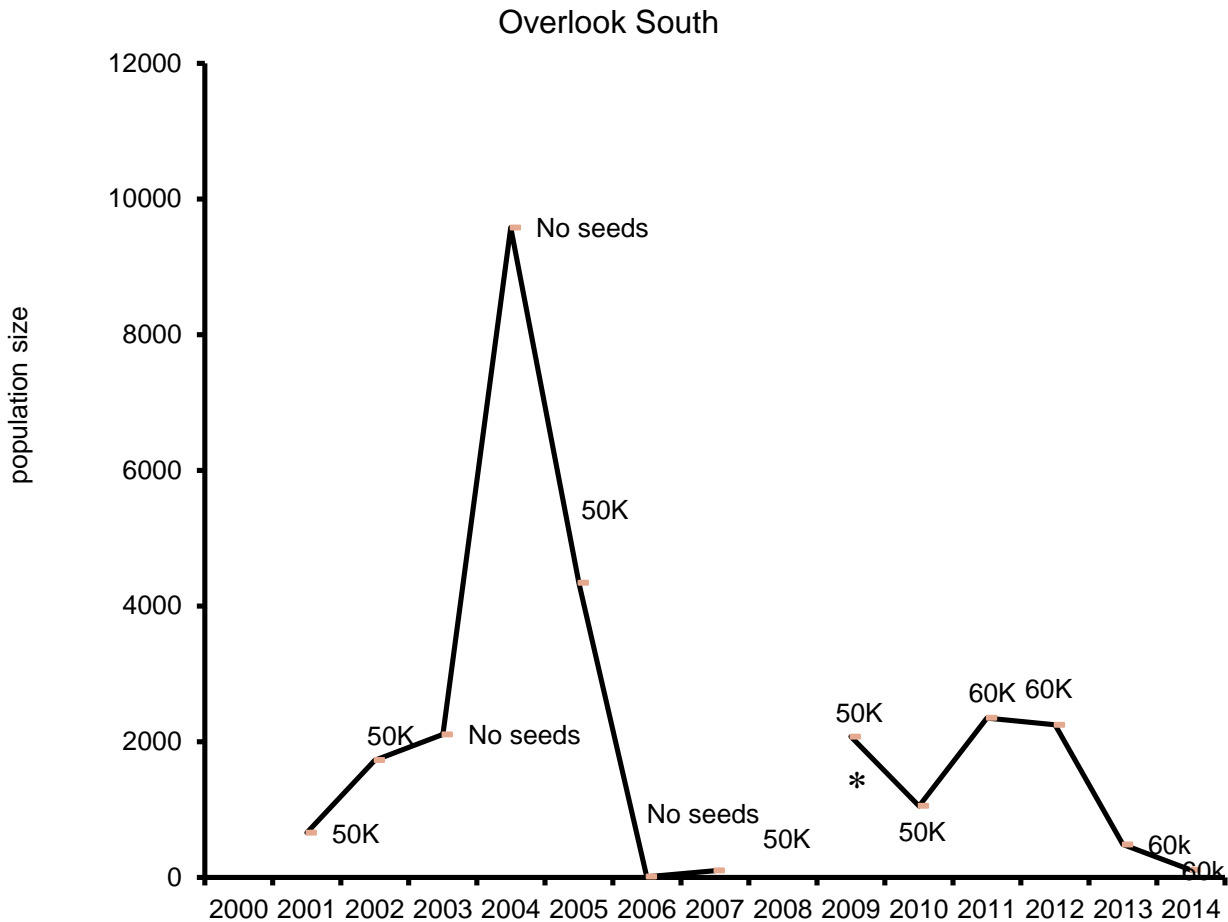


FIGURE 5. TOTAL NUMBER OF PINK SAND-VERBENA PLANTS COUNTED AT SOUTH OVERLOOK SITE, 2000-2014. SEEDING EVENTS ARE MARKED AT EACH APPLICABLE YEAR. * SOUTH OVERLOOK WAS NOT SURVEYED IN 2008 HOWEVER IT WAS SEEDED.

OVERWINTERING PLANTS AT OVERLOOK NORTH AND SOUTH

At the time of seeding in March 2012, a number of robust plants were found apparently overwintering, 18 of these plants were marked with wooden stakes, GPS coordinates and spatial notes relative to the marking stake were taken. Six plants at Overlook North, South and Siltcoos were marked (although more overwintering plants were present at all sites). It is not uncommon for a handful of the usually annual plants to perennate. In the fall these plants were monitored and the longest branch and number of inflorescences counted (if the plant was present).

At both North and South Overlook nearly all overwintering plants were still present in the fall of 2012. At Siltcoos, none of the overwintering plants noted in the spring of 2012 were found in the fall of 2012. The average length of the longest stem on overwintering plants at South Overlook was 96 cm, with an average inflorescence count of 620. This is significantly higher than the average for the rest of the population at South Overlook which had an average longest branch of 24 cm and only 6.3 inflorescences. North Overlook followed a similar pattern with overwintering plants with the average

longest branch of 57 cm and 97 inflorescences compared to 44 cm and 25 inflorescences. It was also noted that the overwintering plants generally had more branches per plant than other plants. In the fall of 2013 these measurements were repeated on any overwintering plants that were still present, (none at Siltcoos and a handful at Overlook.) In 2014, overwintering plants were not monitored.

Bureau of Land Management

Coos Bay North Spit

SEEDING AND MONITORING

Efforts to eliminate European beachgrass from a roughly 170 acre Habitat Restoration Area (HRA) on the Coos Bay North Spit (Figure 3) have included machine ripping and discing (with a tractor), herbicide (Rodeo), burning, saltwater irrigation, hand pulling, and various combinations of these techniques. Ten thousand pink sand-verbena seeds were sown in each of five 30 x 30 m plots randomly placed in areas with different beachgrass management histories on January 15, 1997 (50,000 seeds total). In the winter of 2005-2006 an area closer to the beach on the west side of the access road was cleared of European beach grass. One hundred thousand seeds were added to this area in both 2006 and 2007, 90,000 seeds were added in 2008 and 2009, and 100,000 seeds were added in 2010-2012. All habitat at the North Spit was disced in October (2008) or November (2009-2013).

In 2009, the population had expanded such that a census of the habitat (as performed from 2000-2008) was no longer feasible. We divided the occupied habitat into three sections and sub-sampled within each area counting only reproductive plants. The three areas included 1) the original habitat (Southeast) which includes the reference area used in population counts from 2000-2008 as well as part of the areas censused, 2) the area West of the foredune road, and 3) the area to the north of the original reference area. Starting points for 100m transects were randomly selected within the 3 areas, and sampled as in 2000-2008, counting only reproductive individuals within 1 meter of either side of the tape. In 2012 in the southeast 38 transects were monitored, in the west 20 transects were monitored and in the north 13 transects were monitored. (To see details of sampling methods in previous years, see Thorpe, 2009.)

The total population size was estimated by multiplying the average number of plants per 100 m x 2 m plot (\bar{O}) by the total number of possible plot locations (N):

$$\text{population size estimate} = \bar{O} * N$$

In addition, a 95% confidence interval for this estimate was calculated as:

$$95\% \text{ confidence interval} = \bar{O} \pm [1.96 * \pi(N^2 * SE_0^2 * (N-n/N))]$$

where SE_0 is the standard error of the mean plot density and $N-n/N$ is the finite population correction factor, which is applied because the population area (N) is of limited size (not infinite or extremely large).

In 2012-2014, plant measurements including length of longest branch and the number of inflorescences were collected on 3 plants selected at random along each transect. This data will be used in future years to track changes in plant size and reproductive vigor. To investigate the substrate of the population, the

percent cover of shell within a 0.5 meter radius as well as the number and species of associated plants were recorded.

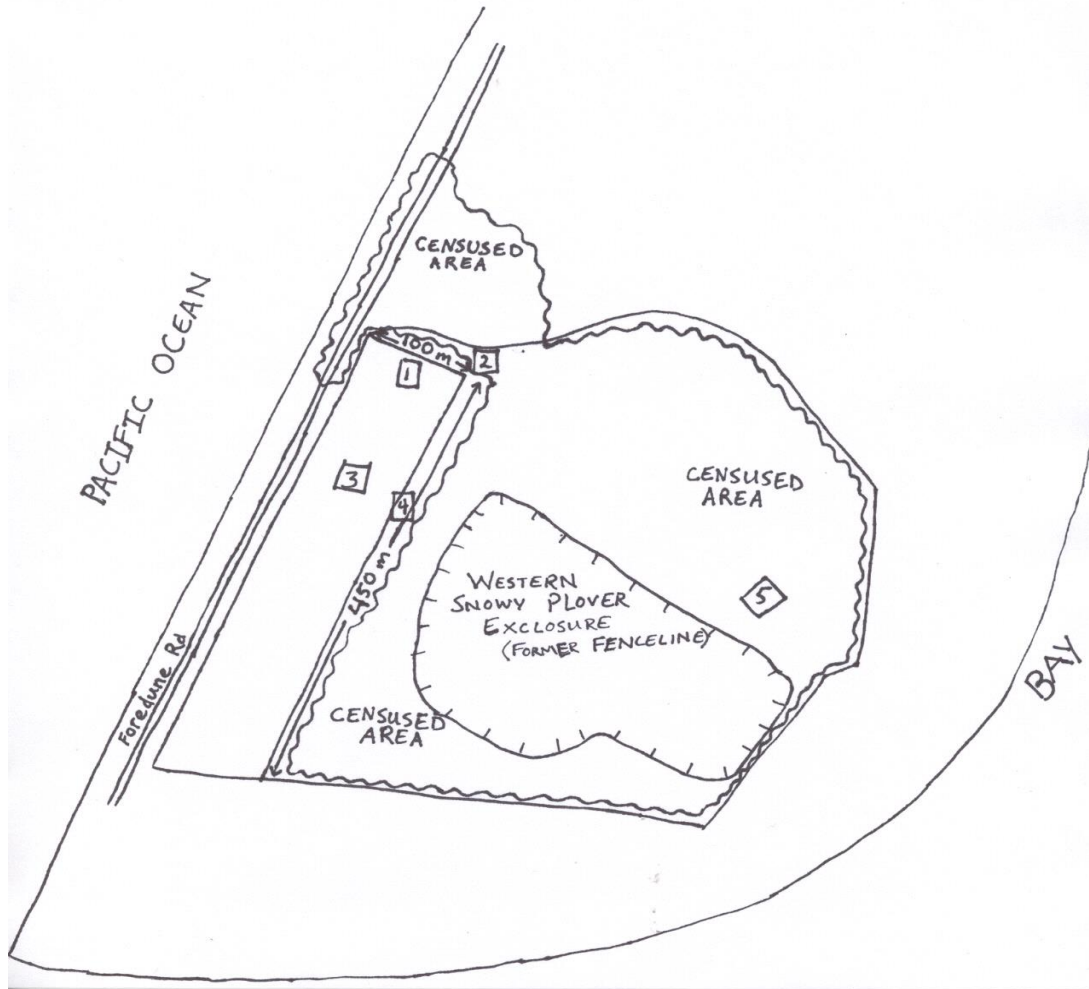


FIGURE 6. COOS BAY NORTH SPIT PINK SAND-VERBENA REINTRODUCTION AREA. THE OPEN SQUARES NUMBERED 1-5 REPRESENT THE ORIGINAL SEEDING PLOTS; 10,000 SEEDS WERE SOWN IN EACH PLOT IN JANUARY 1997. THE LONG RECTANGULAR AREA ON THE WEST SIDE OF THE SPIT IS THE REFERENCE AREA ESTABLISHED IN 2000 (AND EXPANDED IN 2002) USED FOR SUBSAMPLING REPRODUCTIVE PINK SAND-VERBENA ABUNDANCE. THE AREA DELINEATED WITH A WAVY LINE IS CENSUSED INSTEAD OF SUBSAMPLED. NORTH IS TOWARD THE TOP OF THE PAGE. THE AREA SEEDED FROM 2006 TO PRESENT WEST OF THE FOREDUNE ROAD IS NOT SHOWN.

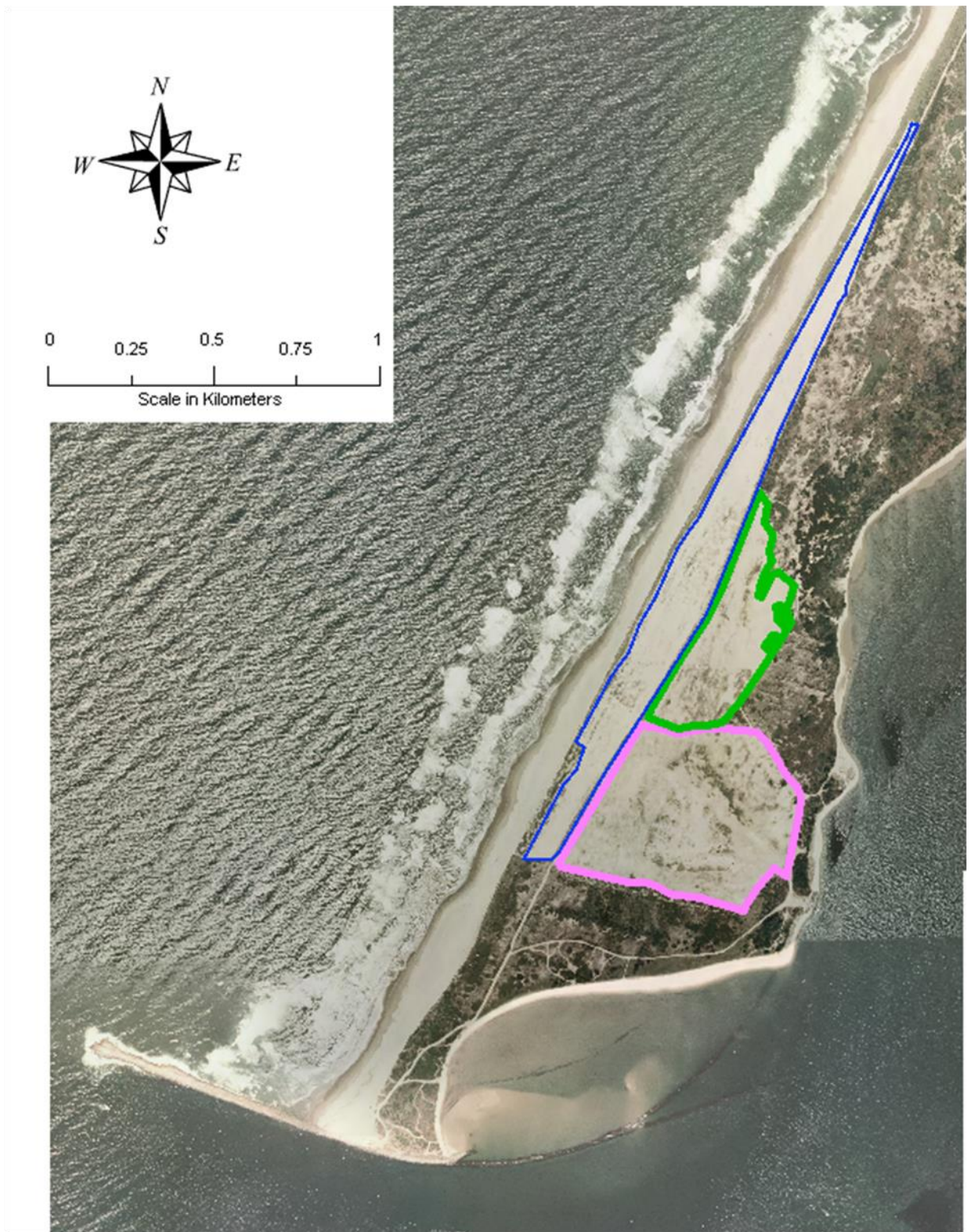


FIGURE 7. IN 2009, THE POPULATED AREA WAS DIVIDED INTO THREE SECTION, 1) THE ORIGINAL HABITAT (SOUTHEAST), 2) NORTHEAST AND 3) WEST OF THE FOREDUNE ROAD. EACH AREA WAS SUBSAMPLED USING THE METHODS DESCRIBED IN THE TEXT.

POPULATION TRENDS

Following re-introduction in 1997, pink sand-verbena populations grew steadily to an estimated peak of 349,658 in 2012 (Figure 8). The dramatic increase in population size from 2007 to 2009 likely is a result of both population growth and improved monitoring techniques initiated in 2009. In 2009, we modified our monitoring technique so that the entire population was subsampled. Despite the large increase in population size from 2011 to 2012, and again in 2014, our observations were consistent with observations made, the size of reproductive plants seems to be diminishing as does seed yield (

Table 3, Table 4), and there was a significant decline in the size of the population from 2012-2013 that coincided with a no discing treatments in the southern portion of the occupied habitat.

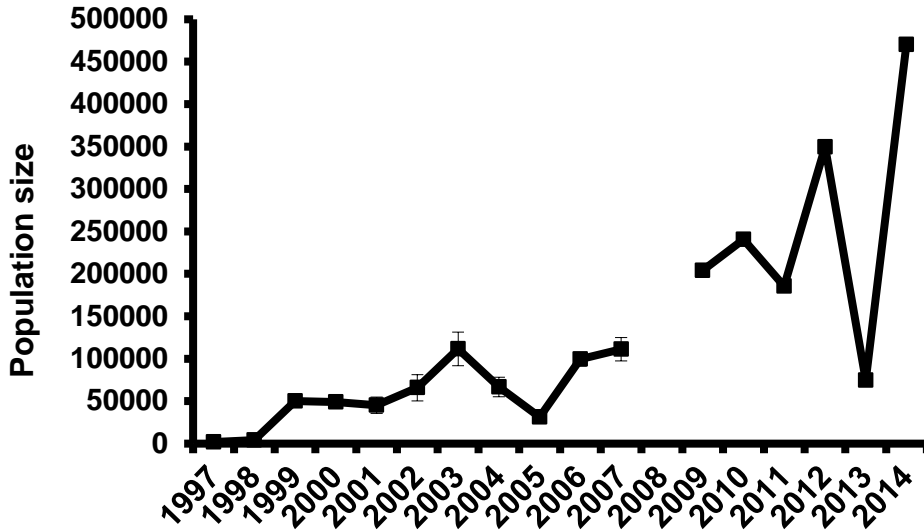


FIGURE 8. POPULATION TRENDS AT THE COOS BAY NORTH SPIT REINTRODUCTION SITE. THE AREA WAS SEEDED IN JANUARY 1997 WITH 50,000 SEEDS FROM PORT ORFORD. POPULATION SIZE ESTIMATES FOR 1997-1999 ARE COMPLETE CENSUSES OF ALL PLANTS IN THE POPULATION, WHILE THOSE FROM 2000-2008 ARE ESTIMATED FROM A SUBSAMPLE OF A REFERENCE AREA AND CENSUS OF THE REMAINDER OF THE POPULATION. THE ERROR BARS FOR 2000-2008 ESTIMATES REPRESENT 95% CONFIDENCE INTERVALS. *IN 2008, AN ESTIMATE OF THE ENTIRE POPULATION SIZE WAS NOT POSSIBLE BECAUSE OVER 50% OF THE POPULATION HAD BEEN DISCED PRIOR TO OUR SURVEYS. SEE TEXT FOR A DISCUSSION OF POPULATION TRENDS. IN 2009, THE SAMPLING METHODS WERE MODIFIED SO THAT THE ENTIRE POPULATION WAS SUB-SAMPLED (AND NO AREAS CENSUSED). IN THIS CHART THE CI FOR 2009-2014 ARE NOT REPORTED BECAUSE THE POPULATION ESTIMATE IS A COMBINATION OF 3 DIFFERENT POPULATIONS, EACH WITH THEIR OWN CI.

In 2012-2014, plant measurements were taken on 3 randomly selected plants along each transect (

Table 3). These data will be used in future years to track changes in plant size and reproductive vigor at the Coos Bay North Spit. In addition to plant measurements, the number and species of plants within 0.5m were recorded as well as the percent cover of oyster shell. In recent years, the number of plants has increased dramatically, however the overall health of pink sand-verbena at the site is thought to be decreasing with less fruits per plant and more small plants. In 2012 it was noted that although there are significantly fewer plants per m² in the west habitat, the plants are significantly larger than those in the rest of the population. Density of plants in the north habitat was the highest at 1.5 plants/m² and lowest on the west side with only 0.05 plants/m² (

Table 3). The average number of fruits per plant varied in the three areas, as did the average plant size with the longest branches and most fruits per plant in the western habitat (

Table 3). Alarming, the density of plants decreased in the southern portion of the habitat that did not receive dicing treatments- highlighting the tenuous hold that the species has- and the importance of continued management for this endangered dune species. In 2014, after management resumed in the southern portion of the habitat, plant density returned to levels observed in previous years (when management occurred).

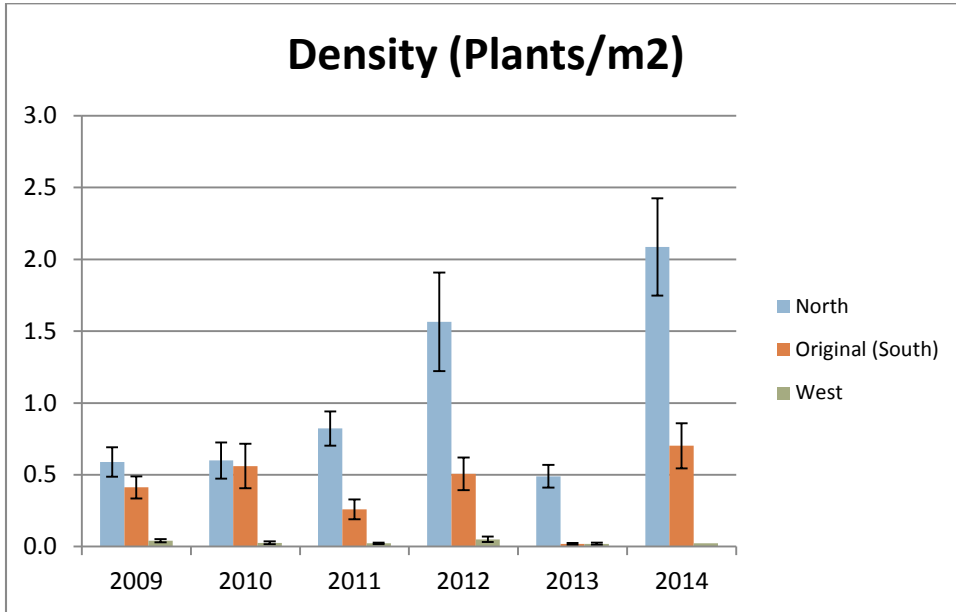


FIGURE 9. DENSITY OF PLANTS PER M2 AT THE COOS BAY NORTH SPIT FROM 2009-2014. NOTE THE SIGNIFICANT DECREASE IN ALL AREAS FROM 2012-2013 THAT COINCIDED WITH LACK OF HABITAT MANAGEMENT.

TABLE 3. AVERAGE LENGTH OF THE LONGEST BRANCH, AVERAGE NUMBER OF INFLORESCENCES AND DENSITY OF PLANTS AT SELECT SITES MONITORED IN 2012. *NUMBER OF REPRODUCTIVE PLANTS FOR COOS BAY NORTH SPIT REPRESENT AN ESTIMATE BASED ON OUR SUBSAMPLES, THE REMAINING VALUES ARE BASED ON CENSUSES DONE AT EACH SITE.

| Site- 2012 | Average Length of Longest Stem (cm) | Average Number of Inflorescences | Occupied Area (m ²) | Number of reproductive plants | Density (plants/m ²) |
|---|-------------------------------------|----------------------------------|---------------------------------|-------------------------------|----------------------------------|
| Coos Bay North Spit, North | 18.6 | 8.6 | 126,558 | 198,063 | 1.5650 |
| Coos Bay North Spit, Southeast (Original) | 14.6 | 8.7 | 275,388 | 139,614 | 0.5070 |
| Coos Bay North Spit, West | 31.7 | 11.7 | 233,758 | 11,746 | 0.0502 |
| New River | 18.8 | 14.7 | 167,423 | 26 | 0.0002 |
| Butte Creek | 29.9 | 41.4 | 107,945 | 10 | 0.0001 |
| Overlook , North | 44.2 | 24.6 | 84,410 | 1,627 | 0.0193 |
| Overlook, North | Overwintering | 56.8 | 97.5 | - | - |
| Overlook, South | 23.6 | 6.3 | 70,569 | 628 | 0.0089 |
| Overlook, South | Overwintering | 96.5 | 620.2 | - | - |
| Tahkenitch | | | 233,547 | 135 | 0.0006 |
| Siltcoos | | | 97,235 | 135 | 0.0014 |
| Elk River | | | 103,225 | 384 | 0.0037 |
| Bandon South | | | 53,859 | 84 | 0.0016 |

The Coos Bay North Spit is now the largest pink sand-verbena population in Oregon and serves as the primary seed source for reintroduction efforts in Oregon. Successful plant establishment and population growth has followed successful control measures for European beach-grass on the spit (described in Pickart and Sawyer [1998] and Kaye [1998]). No beach-grass control was conducted in 2004 and 2005, and the pink sand-verbena population declined in both of those years. In 2008, we observed that many of the plants in the north census area followed the previous year’s disc line (Figure 14), suggesting that the discing may have exposed seeds to the proper conditions for germination. Thus, although the seedbank appears large enough for continual recruitment, the success of this site appears dependent on sustained management activities, particularly annual discing to control plant invasion and additional vegetation control north of the HRA. This pattern was again highlighted in 2013, when the density of pink sand verbena plants decreased from 1.5 to 0.02 /m² in just one year without discing treatment (Figure 9).

However, we have also learned that second year plants can become substantially larger than first year plants if left undisturbed. Therefore, in areas with no European beachgrass and abundant pink sand verbena, we recommend that discing be postponed to allow for some individual plants to reach larger sizes and produce larger amounts of seed. This could be accomplished by lifting the disc on the tractor to skip areas with no beach grass.

TABLE 4. AVERAGE SIZE OF PLANTS IN 2012-2014 AT SELECT SITES.

| | | Butte Creek | Coos Bay North Spit | | | New River | Overlook | |
|-------------|------------------------------|-------------|---------------------|-------|------|-----------|----------|-------|
| | | | North | South | West | | North | South |
| 2012 | Average of Longest stem (cm) | 29.9 | 18.6 | 14.6 | 31.7 | 18.8 | 44.2 | 23.6 |
| | Average of # Flowers | 41.4 | 8.6 | 8.7 | 11.7 | 14.7 | 24.6 | 6.3 |
| 2013 | Average of Longest stem (cm) | - | 20.7 | 33.1 | 29.2 | 24.5 | 24.2 | 33.9 |
| | Average of # Flowers | - | 7.8 | 11.5 | 12.6 | 6.5 | 7.2 | 14.6 |
| 2014 | Average of Longest stem (cm) | - | 16.0 | 16.7 | 24.2 | - | - | - |
| | Average of # Flowers | - | 13.1 | 14.5 | 9.7 | - | - | - |

New River ACEC

SEEDING AND MONITORING

At New River, 50,000-150,000 seeds were dispersed within swales through the foredune almost every year from 1997 to 2011 (Table 1). The spit at New River has been breached in various places by storm waves, creating swales that have low vegetative cover but are bordered on two sides by established plants, primarily European beachgrass. From 1998 to 2005, the BLM made aggressive attempts each fall to reduce the abundance of European beachgrass and lower the foredune using heavy machinery. There was no disturbance in winter 2006 – 2008 and European beachgrass rapidly reinvaded the dunes. Discing resumed winter 2009. Although beachgrass remained throughout the site, the habitat was much more open in 2010 compared to previous years. Discing occurred on a portion of the area in 2010 reducing the cover of beach grass in the disced area. Population surveys occurred in September or October of each year since 1996. Immediately prior to the 1999 site visit, much of the area that had been seeded with pink sand-verbena was worked by a bull dozer to destroy European beachgrass. In the process, an unknown number of pink sand-verbena plants may have been buried, so the estimate of plant abundance at this site in 1999 may be below the actual number present. Estimates of population size from this site were not included in calculations of average plant establishment presented later in this report.

POPULATION TRENDS

The pink sand verbena population at New River has been sustained by direct seeding with 50,000 - 150,000 seeds from 1997-2013 (Figure 10). In the first year of seeding (1997), 118 plants established. Yearly beachgrass control and seeding led to continued population increases to a high of 2,174 plants (1,114 reproductive) in 2005. Beachgrass control did not occur from fall 2005 through spring 2009. Despite repeated seeding, the population declined to 62 plants (42 reproductive and 20 vegetative) in 2009. Beachgrass control resumed fall 2009, and in 2010 (after the distribution of 100,000 seeds) 810 plants were found at the site (369 reproductive) in the fall. These patterns suggest that increased competition from European beachgrass is likely to have contributed to the decrease in population size from 2006-2009. Since 2010, the population has declined, and in 2013, only 33 plants were noted. In 2014, the population rebounded slightly, however numbers remain relatively low for the site with a total of 366 plants (160 reproductive). We recommend that seeding and beachgrass removal efforts continue at this site using the current approach of seeding following disturbance in the fall. In 2012 -14 most plants at the site were found in areas that had been overwashed in winter/spring storms as well as on the shore side of the foredune, highlighting the species affinity for disturbed habitats.

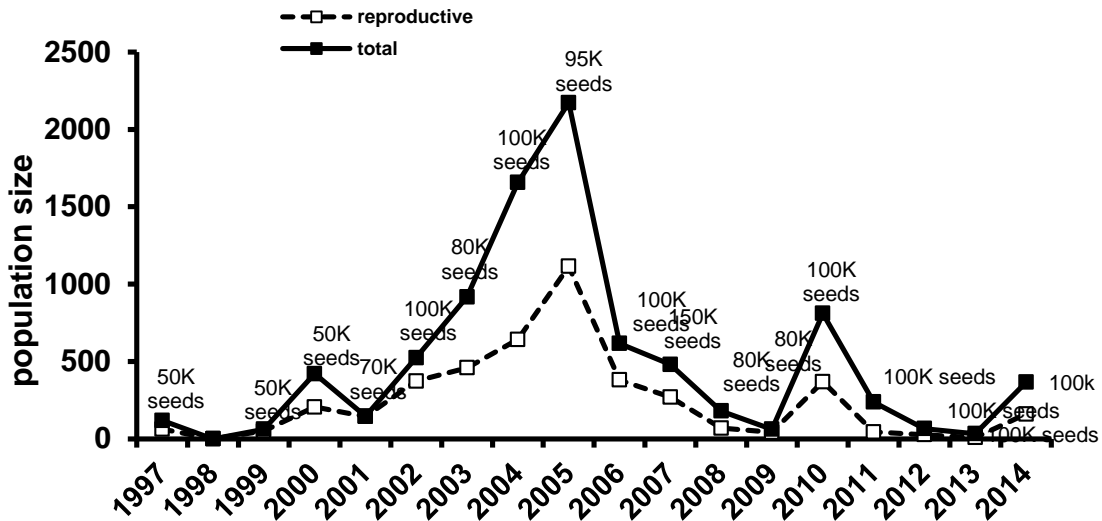


FIGURE 10. POPULATION TRENDS AT THE NEW RIVER ACEC REINTRODUCTION SITE. SEEDING HAS BEEN CONDUCTED IN ALL YEARS EXCEPT 1998.

Oregon Parks and Recreation Department

These sites were not monitored in 2013 or 2014 by IAE staff.

Bandon Beach South

In 2005, a new reintroduction site was established within the HRA approximately one mile south of the China Creek parking area (Appendix II). Prior to reintroduction work in the area, pink sand-verbena plants were located only at the mouth of China Creek.

In 2005, Oregon State Parks removed beachgrass and lowered the foredune in the area. In September 2005, we censused the site and found that although a substantial amount of beachgrass had re-grown into the habitat, 139 pink sand-verbena had become established. The relatively low number of plants in

the project area in 2008 might reflect reduced habitat quality due to regrowth of European beachgrass. However, it is also likely that climate played a significant role. Since 2008 the population has continued to grow. In 2011, 476 plants were found (303 vegetative and 173 reproductive). Many large plants were found on the south end on the protected side of the dunes as in previous years. The majority of plants were in the main beachgrass removal area; however a few plants were found on the beach near the base of the dunes just south of the treatment area. The persistence of plants and strong recruitment in previous years suggests that with continued beachgrass removal, pink sand-verbena reintroduction may be successful at this site. In 2012, the number of plants decreased to just 161 (84 reproductive), this is likely due to the encroachment of beachgrass at the site. Herbicide was applied in the fall of 2012, and it is predicted that the sand verbena population will rebound in the 2013 season in response.

China Creek

The China Creek population has varied substantially since 1998, when the species was first seeded into the site by the Oregon Department of Agriculture. Plants have typically been observed in a protected depression between two large expanses of dunes. We counted 20 reproductive plants at this site in 2006; in 2007, the number declined to 6. Until 2012, no plants had been observed since 2007. In 2012, six plants were found in the China Creek area, 3 vegetative and 3 reproductive. Two plants were found in the creek overwash and the remainder of the plants was found along the north end of the dune and along the edge of Crooked Creek. Poor recruitment at this site could be due to high level of disturbance in the area and the continued invasion of beach grass into the dune system.

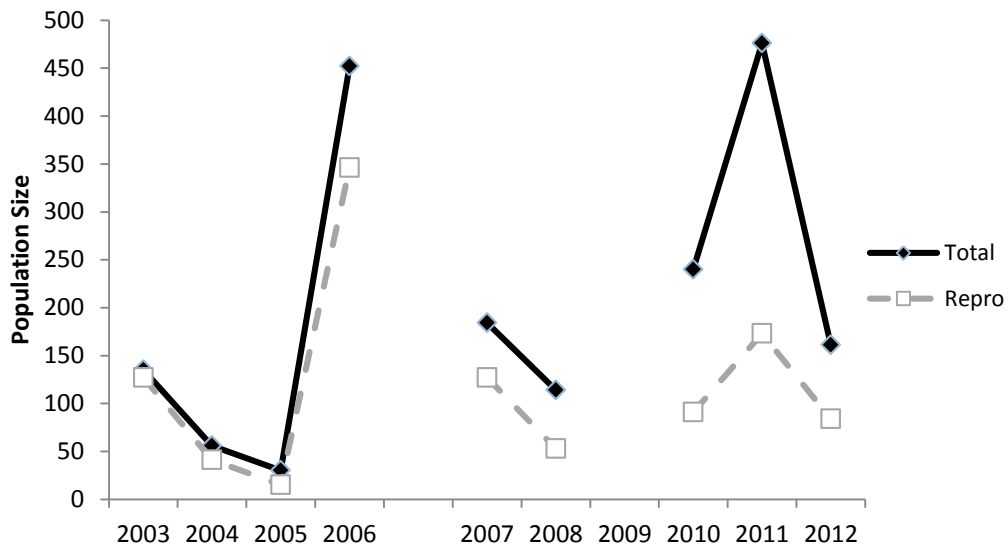


FIGURE 11. POPULATION TRENDS AT BANDON STATE PARK. EUROPEAN BEACHGRASS REMOVAL AND LOWERING OF THE FOREDUNE OCCURRED IN 2005. AT THAT TIME THE AREA WAS SEEDED AND THE NATURAL POPULATION AUGMENTED. THE AREA WAS NOT SURVEYED OR SEEDED IN 2009.

TABLE 5. PLANT SPECIES NATIVE TO OREGON BEACHES AND DUNES: CANDIDATES FOR USE IN ECOSYSTEM RESTORATION PROJECTS. MORE INFORMATION IS NEEDED ON TECHNIQUES FOR GERMINATION AND PROPAGATION OF THESE TAXA.

| Common name | Latin name |
|--------------------------|-------------------------------|
| yellow sand-verbena | <i>Abronia latifolia</i> |
| beach pea | <i>Lathyrus littoralis</i> |
| maritime pea | <i>Lathyrus japonicus</i> |
| beach morning-glory | <i>Convolvulus soldanella</i> |
| silver bursage | <i>Ambrosia chamissonis</i> |
| black knotweed | <i>Polygonum paronychia</i> |
| American dunegrass | <i>Elymus mollis</i> |
| American glehnia | <i>Glehnia leiocarpa</i> |
| silvery phacelia* | <i>Phacelia argentea</i> |
| Wolf's evening primrose* | <i>Oenothera wolfii</i> |
| seaside dock | <i>Rumex maritimus</i> |

*Listed as Threatened with the Oregon Dept. of Agriculture; Species of Concern with the U.S. Fish and Wildlife Service.

Plant Measurements

Table 3 shows the average length of the longest branch and the average number of inflorescences per plant and select sites monitored in 2012. Also included is the estimated density of plants/m² at the sites in 2012, (range 0.001-1.5 plants/m²). Coos Bay North Spit had the highest density of plants overall with a high of 1.5 plants/m² in the northern portion of the population. In contrast, Overlook North (what we consider a fairly successful site) had only 0.02 plants/m². In 2013, plant density was lower at all sites, but the general pattern of density remained the same with Coos Bay North Spit the most dense, and other sites with densities as low as 0.001 plants/m². This general pattern for density was the same in 2014.

The presences and count of plants within a 0.5 m radius of each measured sand-verbena plant was also noted at the North Spit from 2012-2014, and at most sites in 2012 and 2013. There was a total of 17 plant species found growing adjacent to sand-verbena, these species are listed in

Table 6. The most common plant species found within a 0.5 m radius of pink sand-verbena were *Cakile* sp. (Sea rocket) followed by *Ammophila arenaria*, (European beachgrass), *Abronia umbellata* (pink sand-verbena) and *Cammissonia cheiranthifolia* (Beach suncup) (

Table 6). *Leymus mollis* (American beachgrass) was also common at both Overlook sites as well as in the western portion at Coos Bay North Spit. These data will be used to detect changes in plant community at each site as well as allow for comparisons between sites.

TABLE 6. AVERAGE, SUM AND COUNT OF PLANT SPECIES WITHIN 0.5M OF RANDOMLY SELECTED PINK SAND-VERBENA PLANTS IN 2012-2014 AT THE COOS BAY NORTH SPIT. NAMES IN BOLD INDICATE NATIVE SPECIES. *BECAUSE IT IS DIFFICULT TO DISTINGUISH BETWEEN INDIVIDUASL OF BOTH AMERICAN AND EUROPEAN BEACHGRASS, PRESENCE/ABSENCE ONLY WAS NOTED.

| | Count | | | SUM | | | Average | | | % of <i>Abronia</i> with species adjacent | | |
|--|-------|------|------|------|------|------|---------|------|------|---|------|------|
| | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 |
| <i>Abronia umbellata</i> ssp. <i>breviflora</i> | 124 | 37 | 88 | 604 | 145 | 509 | 3.4 | 2.4 | 3.2 | 61% | 71% | 88% |
| <i>Achillea millefolium</i> | 0 | 0 | 1 | 0 | 0 | 1 | 0.0 | 0.0 | 0.0 | 0% | 0% | 1% |
| <i>Anaphalis margaritacea</i> | 3 | 0 | 2 | 21 | 0 | 8 | 0.1 | 0.0 | 0.1 | 15% | 0% | 7% |
| <i>Cakile edentula/maritima</i> | 132 | 29 | 97 | 869 | 73 | 415 | 4.9 | 1.2 | 2.6 | 120% | 50% | 56% |
| <i>Camissonia cheiranthifolia</i> | 66 | 33 | 25 | 145 | 161 | 45 | 0.8 | 2.7 | 0.3 | 20% | 115% | 14% |
| <i>Convolvulus soldanella</i> | 1 | 0 | 1 | 6 | 0 | 7 | 0.0 | 0.0 | 0.0 | 7% | 0% | 9% |
| <i>Fragaria chiloensis</i> | 1 | 2 | 0 | 1 | 2 | 0 | 0.0 | 0.0 | 0.0 | 1% | 5% | 0% |

| | | | | | | | | | | | | |
|-----------------------------|-----|----|----|------|------|------|-----|-----|-----|------|------|------|
| <i>Glehnia littoralis</i> | 6 | 2 | 14 | 8 | 3 | 28 | 0.0 | 0.1 | 0.2 | 4% | 7% | 11% |
| <i>Hypochaeris radicata</i> | 45 | 21 | 41 | 156 | 54 | 105 | 0.9 | 0.9 | 0.7 | 33% | 42% | 27% |
| <i>Juncus lesueurii</i> | 4 | 1 | 2 | 162 | 20 | 16 | 0.9 | 0.3 | 0.1 | 117% | 65% | 19% |
| <i>Lathyrus japonicus</i> | 5 | 3 | 5 | 7 | 4 | 5 | 0.0 | 0.1 | 0.0 | 4% | 8% | 3% |
| <i>Lathyrus littoralis</i> | 1 | 0 | 0 | 1 | 0 | 0 | 0.0 | 0.0 | 0.0 | 1% | 0% | 0% |
| <i>Lupinus littoralis</i> | 22 | 18 | 5 | 26 | 21 | 7 | 0.1 | 0.4 | 0.0 | 6% | 15% | 4% |
| <i>Rumex acetosella</i> | 9 | 10 | 9 | 40 | 213 | 30 | 0.2 | 3.6 | 0.2 | 28% | 405% | 16% |
| | | | | | | | | | | | | |
| <i>Ammophila arenaria</i> | 112 | 31 | 81 | 210 | 80 | 357 | 1.2 | 1.3 | 2.3 | 24% | 41% | 52% |
| <i>Leymus mollis</i> | 14 | 13 | 23 | 14 | 33 | 59 | 0.1 | 0.6 | 0.4 | 4% | 31% | 17% |
| | | | | | | | | | | | | |
| Shell % | 50 | 37 | 85 | 471. | 121. | 501. | 2.6 | 2.0 | 3.2 | 106% | 79% | 109% |
| | | | | 5 | 1 | 3 | | | | | | |
| Wood % | 178 | 31 | 46 | | 20.2 | 49.4 | | 0.3 | 0.3 | | 24% | 18% |

Substrate Assessments

Substrate sample collected in 2012 were analyzed for pH using a Milwaukee pH55 pH meter with accuracy of 0.1 pH units. The unit was calibrated between each measurement. A 50 mg portion of each substrate sample was placed in 100 mL of distilled water and allowed to equilibrate for 10 minutes (and no more than 2 hours,) before a measurement was taken. The pH of the substrate samples ranged from 4.9-8.4. The highest pH values were recorded at the North Spit and in areas where the cover of oyster shell was high (Table 7).

TABLE 7. RANGE AND AVERAGE PH AT SELECT SITES MONITORED IN 2012. NOTE THAT THE SAND FROM THE AREAS WITH COVER OF SHELL GREATER THAN 5% HAD THE HIGHEST PH.

| Site Name | pH Range | Average pH |
|--|----------|------------|
| Coos Bay North Spit (Shell cover < 5%) | 4.6-6.1 | 5.5 |
| Coos Bay North Spit (Shell cover > 5%) | 6.6-8.4 | 7.4 |
| Elk River | 6.4-7.0 | 6.6 |
| Floras Lake | 5.2-5.9 | 5.6 |
| New River | 5.1-5.9 | 5.6 |
| Overlook | 5.4-6.3 | 5.9 |
| Tahkenitch | 5.0-6.0 | 5.6 |

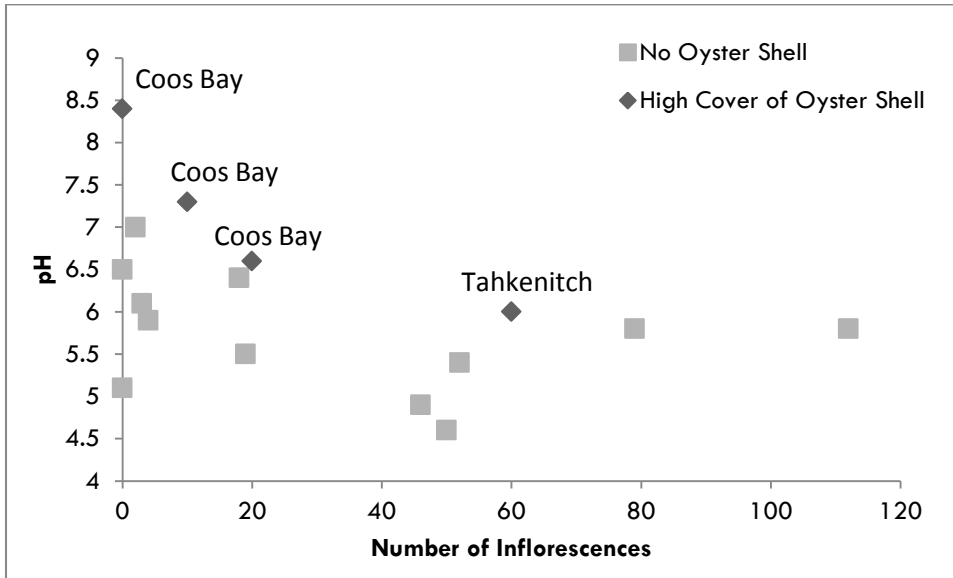


FIGURE 12. NUMBER OF INFLORESCENCES VS. PH OF SUBSTRATE SAMPLES COLLECTED IN 2012. NOTE THAT EXTREME PH VALUES (BOTH HIGH AND LOW) GENERALLY HAVE LOWER NUMBER OF INFLORESCENCES.

DISCUSSION

Transplanting

Transplanting pink sand-verbena can be a successful reintroduction technique. Survival of transplants at Tahkenitch, Siltcoos, and Tenmile averaged 47%, a value typical of earlier transplant efforts at a number of sites. Previous tests of transplant success resulted in an overall average of 51% survival (Kaye 1995, 1996). Factors that affect survival of transplants at any given site appear to include amount of wind blown sand that buries or excavates the plants, moisture availability in the sand at the time of transplanting, and the abundance or proximity of competing vegetation, especially European beachgrass. For example, in 2001, transplants at Tahkenitch did relatively well (76% survival), especially those near the shore and those that did not show evidence of intense wind damage. Transplants at Siltcoos in 2001 were extensively damaged by the wind; their root systems were excavated and overall survival was relatively low survival (16%).

Most pink sand-verbena plants are short-lived (mostly annual). Therefore, the success of populations reintroduced by transplants hinges on recruitment of new individuals from seed produced by the transplants or the planting of additional transplants. So far, offspring from transplants have been relatively uncommon, except after the 1997 Siltcoos transplanting that produced abundant plants the following year (but not subsequently).

Seeding

Similar to the results of the transplanting efforts, we found that seeding was often successful in establishing a pink sand-verbena population the year of seed addition, but that these populations did not usually persist in subsequent years without continued seed additions and beachgrass control. For

example, no plants were present the second year following seeding at New River (1997), Bandon Beach (1998), or Driftwood Creek (1998). However, this obstacle to reintroduction may be addressed through repeated seeding efforts to build up a local seedbank (see seedbank discussion). At four reintroduction sites that have received multiple seeding or transplants attempts, (Siltcoos Creek 2003, Bastendorff Beach 2003, Floras Lake 2004 - 2006, Tahkenitch 2000 - 2004 and Bandon Beach 2003), medium to relatively large numbers of plants have been observed despite no seeding in that year.

The success of seeding is increased with a greater number of seeds. Seeding with 40,000-100,000 (typically 50,000) seeds produced an average of 232 plants per site (0.46% establishment rate), and at least some plants in 84 out of 95 attempts. Earlier seedings with only 5,000 seeds resulted in an average of only 4 plants (0.071% establishment rate), and only 6 of 13 attempts produced at least 1 plant (Kaye 1995, 1998).

The populations at Coos Bay North Spit and the Overlook sites are examples of reintroductions into beachgrass control areas that have done remarkably well. In 1996, 50,000 seeds were distributed at the Coos Bay North Spit. The population quickly grew from over 1,700 plants in 1997, to 4,111 in 1998 and at least 50,000 in 1999. From 2000 on, the plants were so abundant that a reference area was subsampled with randomly placed plots (Figure 3) and the abundance of the species in the rest of the spit was counted. Since vegetative plants do not contribute to the population (pink sand-verbena is usually an annual) and counting all plants would be infeasible because of time constraints, we counted only reproductive individuals at this site since 2000. It is important to note that in 2004 and 2005 and again in 2013, the Coos Bay North Spit population declined significantly, which may be due to the lack of beachgrass management during the prior fall and winter. *Without repeated discing to reduce invading vegetation such as European beachgrass, pink sand-verbena may fail to increase in numbers and expand its area at this site.* The total reproductive plant abundance in 2014 was estimated at 470,092, the highest population size recorded to date at any known site—however in 2013 the population declined to only 74,805 (95% C.I. 25,269), and this is in large part due to declines in the portion of the habitat that did not receive management treatment.

At Coos Bay North Spit in recent years there has been an increase in the number of plants in the original habitat and in the northern area and an expansion of the habitat to include an area west of the foredune road, however, the size of the plants has decreased since initiation of this study. This could be due to a number of factors including; annual variability in the populations due to climactic factors, intra-specific competition, competition with other annuals including *Cakile edentula*, *Cakile maritima* and *Hypochaeris radicata*, a decrease in the availability of nutrients, the timing and intensity of discing and plowing, a change in the pH caused by the oyster shells and the possible (if unlikely) presence of a contaminant on the oyster shells brought in for the plover habitat. In 2012 and 2013 our monitoring at North Spit included some plant measurements which will serve as a baseline for comparison in the future.

We have occasionally observed plants in the interior of the beachgrass control zone at Coos Bay North Spit, on the lee side of the eastern dune edge at Overlook, and in other protected areas at several sites that had over-wintered from the year before. These plants achieved very large sizes (>2 m²) and produced copious amounts of seed. *Data collected in 2012 and 2013 indicates that overwintering plants are both significantly larger and produce more seed than annual plants and may play an important role in developing a natural seedbank.*

As with transplanting, the success of seeding may be related to habitat quality and susceptibility to the scouring effects of winter storms. For example, the presence of competing vegetation, especially in foredune habitats, may result in small plants that produce few or no seeds. Also, winter storms on the Oregon coast can have dramatic effects on beaches, removing large amounts of sand and even established foredunes. Any plants or recently deposited seeds on a beach could be removed from the site and carried away on ocean currents. For example, the seeding attempt at Floras Lake in 2000 resulted in only ten plants, but the beach at this site is subject to strong surf and winter storms, as evidenced by coarse sand and a short shelf and steep slope on the beach. Also, some recent winters in Oregon have been characterized by La Niña climatic patterns that include more frequent and intense winter storms. Harsh winters in 1997-2000 may have resulted in less population carryover after seeding attempts. The habitats at the Coos Bay North Spit and the Overlook sites are protected from these winter storms.

At the North Spit, the population is located in the interior of the sand spit and at the Overlook site, populations are on the elevated foredune. This protection allows all seeds produced from the pink sand-verbena plants that grow there to remain on site, maximizing their chances of establishing seedlings the following year. Furthermore, the habitat at the Overlook site has repeatedly been disturbed during fall and winter months each year since seeding in 1996. This disturbance, which included discing and manual removal of beachgrass (Kaye 1998), has kept competing plant species from revegetating the site and has probably been crucial to the successful population growth of pink sand-verbena. Initial plant establishment at the Coos Bay North Spit in 1997 was highly negatively correlated with the local abundance of European beachgrass (Kaye 1998). Competition studies at Port Orford and Gold Beach on dredge material also suggest that competing vegetation is a major factor affecting establishment and survival of pink sand-verbena (Kaye 1999).

Importance of a seedbank

Long-term persistence of pink sand-verbena at sites on the Oregon coast may depend on the development and maintenance of a long-lived persistent seedbank. Results from germination tests with seeds of various ages (stored in paper sacks at room temperature) show that seeds of this species can remain viable for long periods of time. Loss of viability over time appears to be very slow; seeds stored for nine years retained over 80% viability (Figure 13).

The stochastic behavior of natural and reintroduced pink sand-verbena populations suggests that seedbanks buffer populations from sharp declines and can allow re-colonization of a site. At Otter Point, a population decline to zero plants in 2000 was followed by the emergence of three plants in 2001; seven plants were counted at Cape Blanco in 2004 although none had been observed there in 2003. Seeding in 2002 at three reintroduction sites, Siltcoos Creek, Bastendorff Beach, and Bandon Beach, resulted in low plant establishment (fewer than 20 plants each) that year, but much higher populations (>100 plants) in 2003 without additional seeding. The appearance of some populations of pink sand-verbena long distances from natural populations, such as at Tenmile in 1995, Gearhart in 1993, and Vancouver Island in 2000 (after nearly 60 years of absence), suggest that some populations may establish from seed many years after the presence of any adult plants. Two new sightings (Tish-A-Tang and Arizona Beach) this year indicate that seeds may establish from the seedbank. Taken together, these lines of evidence provide strong support for the notion that pink sand-verbena is capable of maintaining

a persistent seedbank, and that buried seeds may play an important role in the population dynamics of this species and should be fostered in reintroduction attempts.

Plant Measurements

In 2012-2014 measurements taken on randomly selected reproductive plants at Overlook, Coos Bay North Spit and New River were taken. This data will be used in the future to track changes in the population of pink sand-verbena as well as the associated plant community.

Substrate Assessments

Preliminary work in 2012 shows that addition of oyster shells may cause changes in pH. Substrate samples collected from areas with high cover of oyster shell were also associated with higher pH levels and smaller pink sand-verbena with few inflorescences (Table 7 and Figure 12). Future research could focus on evaluating (a)biotic habitat factors that influence the success of introduced and existing sand-verbena populations.

Additional Research

Population modeling to assess recovery objectives

The Conservation Strategy for pink sand-verbena (Kaye 2006) calls for the development of recovery objectives that take into account our ability to successfully reintroduce populations of the species. However, we have no estimate of the number of populations needed to establish a successful pink sand-verbena meta-population. Data gathered from population monitoring on natural population dynamics, population establishment success, and estimations of dispersal rates can be used to simulate population dynamics over time. Through the use of matrix models, the viability of individual populations may be estimated based on observations of individuals in populations through time. Pink sand-verbena may be a suitable 'model system' for structuring reintroduction programs and setting objectives, especially for rare beach plant species.

Restoration with additional beach species

Pink sand-verbena is only one of several beach species in decline on the Oregon coast. Efforts to control European beachgrass to improve habitat conditions for native species such as pink sand-verbena and the western snowy plover create large, open areas devoid of vegetation (if successful), similar to the type of habitats that were plentiful prior to beachgrass introduction. These areas would also likely provide good habitat for other native beach and dune plant species. Unfortunately, propagation methods for many beach species have not been developed. A preliminary list of 11 native plant species that could be useful in restoration projects of beach ecosystems is provided in Table 8.

Hypotheses for Future Research

The results of attempts to reintroduce pink sand-verbena to beach and dune habitats in Oregon, combined with observations made during field visits, have led to several hypotheses that require further testing before they can be used to guide additional reintroduction efforts.

Recently deposited or disturbed sand is a more suitable substrate for pink sand-verbena growth than older substrates. Natural and transplanted plants at Port Orford and Gold Beach consistently thrived on freshly deposited dredge material, but tended to decline in vigor two to three years after the sand was deposited. In 1995 at Coos Bay North Spit, transplants placed in an area that had recently (within three months) been disturbed during treatment for beachgrass thrived and achieved large size (greater than 50-cm) with substantial flowering (over 50 inflorescences each) while plants transplanted in an area where beachgrass had been removed two years before showed only moderate survival and growth. Furthermore, natural populations in southern Oregon and northern California often occur near the mouths of rivers and creeks where fresh sand is consistently deposited and disturbance is frequent.

Plants that grow close to shore (on the upper beach) are more likely to thrive in the short-term, but plants in the foredune are more likely to survive fall and winter storms. Observations of mortality patterns of transplants at Tillamook Bay and Hubbard Creek, where plants were positioned in sets both on the upper beach and in the foredune, suggest that the upper beach can be a very suitable (even superior) habitat for growth. However, fall and late summer storms damaged vigorous plants on the upper beach. The foredune transplants were not damaged and continued to thrive into fall (as late as November), and may survive the winter. Additional evidence suggests that competition from dune grasses can be detrimental to pink sand-verbena growth. Therefore, a strategy that places transplants among both habitats may improve overall success.

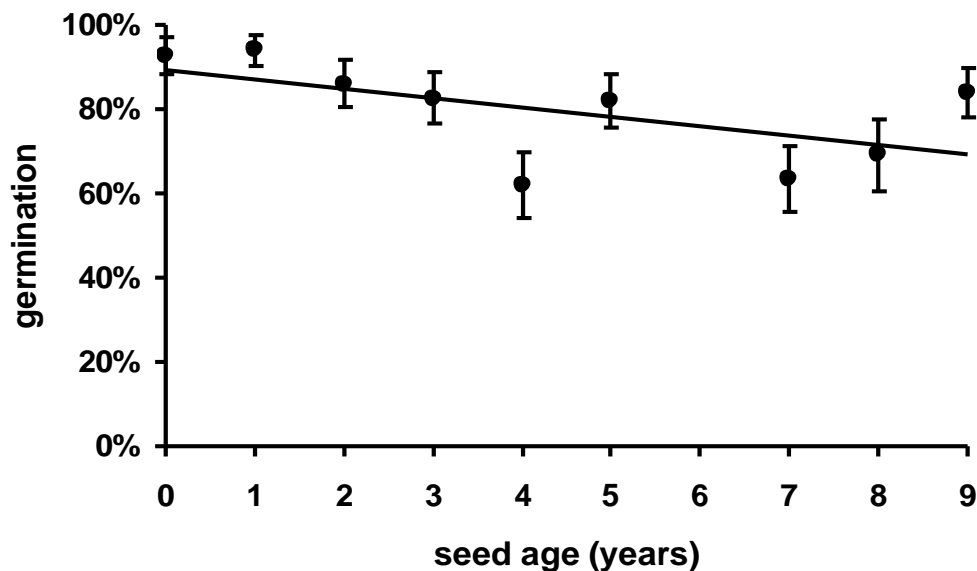


FIGURE 13. THE PERCENT OF SEEDS STORED FROM 0-9 YEARS. THE EQUATION FOR THE LINEAR REGRESSION IS $Y = -0.03X + 0.955$, $R^2 = 0.81$, $P = 0.015$.

TABLE 8. PLANT SPECIES NATIVE TO OREGON BEACHES AND DUNES: CANDIDATES FOR USE IN ECOSYSTEM RESTORATION PROJECTS. MORE INFORMATION IS NEEDED ON TECHNIQUES FOR GERMINATION AND PROPAGATION OF THESE TAXA.

| Common name | Latin name |
|--------------------------|-------------------------------|
| yellow sand-verbena | <i>Abronia latifolia</i> |
| beach pea | <i>Lathyrus littoralis</i> |
| maritime pea | <i>Lathyrus japonicus</i> |
| beach morning-glory | <i>Convolvulus soldanella</i> |
| silver bursage | <i>Ambrosia chamissonis</i> |
| black knotweed | <i>Polygonum paronychia</i> |
| American dunegrass | <i>Elymus mollis</i> |
| American glehnia | <i>Glehnia leiocarpa</i> |
| silvery phacelia* | <i>Phacelia argentea</i> |
| Wolf's evening primrose* | <i>Oenothera wolfii</i> |
| seaside dock | <i>Rumex maritimus</i> |

*Listed as Threatened with the Oregon Dept. of Agriculture; Species of Concern with the U.S. Fish and Wildlife Service.

A persistent seedbank may be a necessary component of a viable population; repeated seedings or transplantings may be required for successful reintroduction and recovery. Pink sand-verbena seeds are long-lived and appear to be capable of persistence in beach sands for long periods of time (up to several decades). Therefore, buried seeds may play an important role in viable populations of pink sand-verbena, acting as a mechanism for population re-establishment after catastrophes or stochastic swings in population size. They may also serve to provide some genetic stability to populations by containing samples of genetic variability that are occasionally lost from the above-ground population. Successful reintroduction of this species may require the development of a large pool of buried seeds, so that introduced populations can rebound after periods of population decline. This suggests that at each site, repeated seedings or transplantings over several years may be required to build-up a seedbank.

Overwintering plants play an important role in the creation of a self-sustaining population. Large overwintering plants are larger and produce significantly more seed than annual plants under some conditions. Mechanical methods of discing and bulldozing commonly used for invasive beach grass control at many of the sand-verbena sites may need to be balanced with the need to allow at least some plants to overwinter and grow for a second year. Manual removal (where feasible), targeted herbicide use, or staggered discing treatments are possible ways to allow for both the control of beach grass and for some sand verbena plants to perennate. Especially in habitat patches where beachgrass is not established in any given year, lifting the disc equipment temporarily may allow more second year plants to flourish.

RECOMMENDATIONS FOR 2015

In 2014 seeds were collected from Coos Bay by IAE, BLM staff and volunteers, for distribution in 2015. Based on the success of seeding and transplant efforts in previous years, we recommend that the following sites be the focus of seeding and restoration efforts in 2015:

| Management Agency | Site | Seeding Conducted in 2014 | Recommended Action. 2015 |
|---|------------------------|----------------------------------|---------------------------------|
| US Forest Service, Siuslaw N.F. | Siltcoos Creek | 10,500 | 50,000 |
| | Overlook, North | 60,000 | 60,000 |
| | Overlook, South | 60,000 | 60,000 |
| | Tahkenitch | 40,000 | 100,000 |
| Bureau of Land Management, Coos Bay | New River | 100,000 | 100,000 |
| | Coos Bay North Spit | 100,000 | 100,000 |
| Private land (managed by USFWS) | Elk River | 100,000 | 100,000 |
| Oregon Parks and Rec. (restoration by USFWS) | Bandon Natural Area | 100,000 | 100,000 |

We recommend that population surveys be conducted at the following sites in the fall of 2015:

| County | Site |
|----------------|--------------------------|
| Lane County | Siltcoos Creek |
| " | Sutton Creek |
| Curry County | Cape Blanco |
| " | Elk River |
| " | Euchre Creek (Ophir) |
| " | Floras Lake |
| " | New River |
| " | Otter Point |
| " | Port Orford |
| Douglas County | Overlook North and South |
| Coos County | Bandon Beach China Creek |
| " | Bandon Beach South |
| " | Coos Bay North Spit |
| Lincoln county | Salmon River |

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APPENDIX I. MATERIALS REQUIRED FOR POPULATION MONITORING

pin flags

data sheets

GPS

previous year's report

6 100m tapes (Coos Bay only)

Flagging

Candy canes

APPENDIX II. SURVEY RESULTS FOR SEEDED AND NATURAL POPULATIONS

TABLE 9. RESULTS OF SURVEYS FOR PINK SAND-VERBENA AT COOS BAY DISTRICT BUREUA OF LAND MANAGEMENT SITES ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

| Site | natural or reintroduced | date surveyed | population size | Reintroduction history and other comments |
|-----------|-------------------------|---------------|---|---|
| Coos Bay | reintro. | 9/26/2012 | ~349,658 (repro.) | Seeded (100K seeds) |
| | | 10/6/2011 | ~185,623 (repro.) | Seeded (100K seeds) |
| | | 9/22/2010 | ~240,488 (repro.) | Seeded (100K seeds) |
| | | 10/14/2009 | ~203,959 (repro.) | Seeded (90K seeds) |
| | | 10/15/2008 | >10,929 (repro.)* | Seeded (90K seeds) |
| | | 2007 | ~111,063 (repro.) | Seeded (100K seeds) |
| | | 9/27/2006 | ~99,354 (repro.) | Seeded (100K seeds) |
| | | 10/3/2005 | ~31,411 (repro.) | --- |
| | | 10/12/2004 | ~66,697 (repro.) | --- |
| | | 10/2/2003 | ~111,496 (repro.) | --- |
| | | 9/25/2002 | ~65,922 (repro.) | --- |
| | | 9/14/2001 | ~45,257 (repro.) | --- |
| | | 9/19/2000 | ~45,000 (repro.) | --- |
| | 1996 | --- | Seeded (50K seeds) | |
| New River | reintro. | 9/27/2012 | 66 plants (26 repro., 40 veg.) | Seeded (120k seeds) |
| | | 10/5/2011 | *237 plants (44 repro., 193 veg.) | Seeded (100k seeds) |
| | | 9/21/2010 | 810 plants (369 repro., 441 veg.) | Seeded (100K seeds) |
| | | 10/5/2009 | 62 plants (42 repro., 20 veg.) | Seeded (80K seeds) |
| | | 10/16/2008 | 180 plants (69 repro., 111 veg.) | Seeded (80K seeds) |
| | | 9/29/2007 | 480 plants (269 repro., 211 veg.) | Seeded (150K seeds) |
| | | 9/25/2006 | 616 plants (380 repro., 236 veg.) | Seeded (100K seeds) |
| | | 10/4/2005 | 2,174 plants (1,114 repro., 1,058 veg.) | Seeded (95K seeds) |
| | | 9/14/2004 | 1,628 plants (1,014 repro., 614 veg.) | Seeded (100K seeds) |
| | | 10/1/2003 | 917 plants (459 repro., 458 veg.) | Seeded (80K seeds) |
| | | 9/11/2002 | 524 plants (373 repro., 151 veg.) | Seeded (100K seeds) |
| | | 9/12/2001 | 145 plants | Seeded (70K seeds) |
| | | 8/15/2000 | 421 plants | Seeded (50K seeds) |
| | 1999 | --- | Seeded (50K seeds) | |
| | 1997 | --- | Seeded (50K seeds) | |

*In 2008, due to early discing, <50% of the pop. was surveyed, thus 2008 cannot be accurately compared to estimates in other years.

* A portion of the area had been newly discd expanding the suitable habitat since 2010

TABLE 10. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES MANAGED BY THE SIUSLAW NATIONAL FOREST ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

| Site | natural or reintroduced | date surveyed | population size | Reintroduction history and other comments |
|----------------|-------------------------|---------------|--|--|
| Tahkenitch Cr. | reintro. | 10/1/2012 | 381 plants (135 repro., 246 veg.) | Seeded (100k seeds) |
| | | 10/5/2011 | 95 plants (38 repro., 57 veg.) | Seeded (80k seeds) |
| | | 10/2009 | 4 plants (2 repro., 2 veg.) *briefly surveyed by Marty Stein 1 veg. | --- |
| | | 10/4/2006 | 0 plants | --- |
| | | 9/14/2005 | 121 plants (72 repro., 49 veg.) | Seeded (50K seeds) |
| | | 9/29/2004 | 0 plants | Seeded (50K seeds) |
| | | 9/18/2003 | 22 plants (14 repro., 8 veg.) | --- |
| | | 9/25/2002 | 50 plants (45 repro., 5 veg.) | Seeded (50K seeds) |
| | | 9/18/2001 | 32 plants (repro.) | Seeded (50K seeds) +50 transplants 50 transplants |
| | | 9/20/2000 | | |
| Overlook North | reintro. | 10/1/2012 | 4,860 plants (1,627 repro., 3,233 veg.) | Seeded (60k seeds) |
| | | 10/4/2011 | 1,938 plants (794 repro., 1,194 veg.) | Seeded (60k seeds) |
| | | 9/26/2010 | 730 plants (238 repro., 492 veg.) | Seeded (50K seeds) |
| | | 10/6/2009 | 789 plants (466 repro., 323 veg.) | Seeded (50K seeds) |
| | | 10/2/2008 | 2,395 plants (811 repro., 1,584 veg.) | Seeded (100K seeds) |
| | | 9/24/2007 | 3,445 plants (2,790 repro., 655 veg.) | Seeded (80K seeds) |
| | | 10/4/2006 | 7,825 plants (1,976 repro., 5,840 veg.) | --- |

Abronia umbellata var. *breviflora* on the Oregon coast: Reintroduction and population monitoring

| | | | | |
|----------------|----------|-----------|---|--|
| | | 9/14/2005 | 3,210 plants (1,191 repro., 2,019 veg.) | --- |
| | | 9/29/2004 | 3,741 plants (2,632 repro., 1,109 veg.) | --- |
| | | 9/18/2003 | 1,478 plants (1,359 repro., 119 veg.) | --- |
| | | 9/25/2002 | 1,091 plants (574 repro., 517 veg.) | --- |
| | | 9/18/2001 | 482 plants (390 repro., 92 veg.) | Seeded (50K seeds) |
| | | 9/20/2000 | 2 plants (repro.) | 50 transplants (most pulled by accident) |
| Overlook South | reintro. | 10/1/2012 | 2,247 plants (628 repro., 1,619 veg.) | Seeded (60k seeds) |
| | | 10/4/2011 | 2,349 plants (988 repro., 1,361 veg.) | Seeded (60k seeds) |
| | | 9/26/2010 | 1,052 plants (424 repro., 628 veg.) | Seeded (50K seeds) |
| | | 10/6/2009 | 2,073 plants (1518 repro., 555 veg.) | Seeded (50K seeds) |
| | | 2008 | Informal survey noted plants as present | Seeded (50K seeds) |
| | | 9/24/2007 | 98 plants (76 repro., 22 veg.) | Seeded (50K seeds) |
| | | 10/4/2006 | 10 plants (4 repro., 6 veg.) | --- |
| | | 9/14/2005 | 4,340 plants (2,581 repro., 1,759 veg.) | Seeded (50K seeds) |
| | | 9/29/2004 | 9,554 plants (6,325 repro., 3,229 veg.) | --- |
| | | 9/18/2003 | 2,107 plants (1,954 repro., 153 veg.) | --- |
| | | 9/25/2002 | 1,726 plants (1,435 repro., 291 veg.) | Seeded (50K seeds) |
| | | 9/18/2001 | 658 plants (427 repro., 231 veg.) | Seeded (50K seeds) |
| Baker Beach | reintro. | 10/6/2009 | 6 plants (5 repro., 1 veg.) | Seeded (40K seeds) |
| | | 10/2/2008 | 70 plants (32 repro., 38 veg.) | Seeded (50K seeds) |
| | | 9/24/2007 | 42 plants (30 repro., 12 veg.) | Seeded (50K seeds) |
| | | 9/5/2006 | 12 plants (6 repro., 6 veg.) | Seeded (50K seeds) |
| | | 9/14/2006 | 72 plants (11 repro., 61 veg.) | Seeded (50K seeds) |

| | | | | |
|--------------|-----------------------|------------|-----------------------------------|---------------------|
| | | 05 | | |
| | | 10/28/2004 | 93 plants (37 repro., 56 veg.) | Seeded (50K seeds) |
| | | 9/18/2003 | 55 plants (27 repro., 28 veg.) | Seeded (50K seeds) |
| Siltcoos Cr. | reintro. | 10/1/2012 | 605 plants (135 repro., 470 veg.) | Seeded (50K seeds) |
| | | 10/5/2011 | 415 plants (309 repro., 106 veg.) | Seeded (100K seeds) |
| | | 9/27/2010 | 148 plants (28 repro., 120 veg.) | Seeded (50K seeds) |
| | | 10/6/2009 | 36 plants (15 repro., 21 veg.) | Seeded (55K seeds) |
| | | 10/2/2008 | 41 plants (14 repro., 27 veg.) | Seeded (60K seeds) |
| | | 9/24/2007 | 66 plants (54 repro., 12 veg.) | Seeded (100K seeds) |
| | | 10/4/2006 | 385 plants (202 repro., 183 veg.) | Seeded (50K seeds) |
| | | 9/14/2005 | 989 plants (961 repro., 28 veg.) | Seeded (50K seeds) |
| | | 10/28/2004 | 355 plants (311 repro., 44 veg.) | Seeded (50K seeds) |
| | | 9/18/2003 | 215 plants (195 repro., 20 veg.) | --- |
| | | 9/25/2002 | 19 plants (12 repro., 7 veg.) | Seeded (60K seeds) |
| | | 9/18/2001 | 7 plants (all repro.) | 45 Transplants |
| | | 9/20/2000 | 249 plants (135 repro., 114 veg.) | Seeded (50K seeds) |
| | | 1999 | --- | Seeded (50K seeds) |
| Sutton Creek | reintro. | 9/24/2007 | 0 plants | --- |
| | | 9/5/2006 | 0 plants | Seeded (50K seeds) |
| | | 2005 | 0 plants | Seeded (50K seeds) |
| | | 10/28/2004 | 150 plants (28 repro., 122 veg.) | Seeded (50K seeds) |
| Tenmile Cr. | natural and augmented | 10/23/2003 | 1 plant (repro.) | --- |
| | | 9/25/2002 | 0 plants | --- |

| | | |
|---------------|----------|-----------------|
| 9/18/20 01 | 0 plants | --- |
| 9/20/20 00 | 0 plants | --- |
| 1999 | --- | 150 transplants |

TABLE 11. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES MANAGED BY THE OREGON DEPARTMENT OF PARKS AND RECREATION ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

| Site | natural or reintroduced | date surveyed | population size | Reintroduction history and other comments |
|----------------------------|-------------------------|-----------------------|-----------------------------------|---|
| Bandon Beach South | reintro. | 9/27/2012 | 161 plants (84 repro., 77 veg.) | Seeded (100K seeds) |
| | | 10/2011 | 476 plants (173 repro., 303 veg.) | Seeded (100K seeds) |
| | | 9/21/2010 | 260 plants (91 repro., 149 veg.) | Seeded (120K seeds) |
| | | 10/14/2008 | 113 plants (52 repro., 61 veg.) | Seeded (50K seeds) |
| China Creek (Bandon Beach) | | 9/27/2012 | 6 plants (3 repro., 3 veg.) | --- |
| | | 9/13/2007 | 173 plants (121 repro., 52 veg.) | Seeded (50K seeds) |
| | | 9/26/2006 | 452 plants (346 repro., 106 veg.) | Seeded (50K seeds) |
| | | 10/4/2005 | 139 plants (124 repro., 15 veg.) | Seeded (100K seeds) |
| Bastendorff Beach | reintro. | 9/21/2010 | 2 plants (2 repro., 0 veg.) | --- |
| | | 10/15/2008 | 9 plants (6 repro., 3 veg.) | --- |
| | | 9/13/2007 | 2 plants (repro.) | --- |
| | | 9/26/2006 | 11 plants (8 repro., 3 veg.) | --- |
| | | 10/5/2005 | 536 plants (410 repro., 126 veg.) | Seeded (50K seeds) |
| | | 9/13/2004 | 371 plants (245 repro., 126 veg.) | Seeded (50K seeds) |
| | | 10/2/2003 | 110 plants (104 repro., 6 veg.) | --- |
| | | 9/11/2002 | 13 plants (8 repro., 5 veg.) | Seeded (50K seeds) |
| | | 8/15/2000 | 0 plants | --- |
| | | 1998 | --- | Seeded (50K seeds) |
| 1997 | --- | Seeded (50K seeds) | | |
| 1996 | --- | Seeded & transplanted | | |
| 1995 | --- | Seeded & transplanted | | |

Abronia umbellata var. breviflora on the Oregon coast: Reintroduction and population monitoring

| | | | | |
|-------------------------|----------|-----------------|-----------------------------|---|
| Harris Beach State Park | natural | 9/15/2004 | 0 plants | Natural pop'n, but also seeded (5,000 seeds) in 1995 and transplanted |
| | | 9/10/2002 | 0 plants | |
| | | 9/13/2001 | 0 plants | |
| | | 8/16/2000 | 0 plants | |
| McVay Park | natural | 8/16/2000 | 0 plants | appeared unsuitable |
| Pistol River | reintro. | 10/5/2009 | 0 plants | --- |
| | | 10/14/2008 | 1 veg. | Seeded (80K seeds) |
| Euchre Creek (Ophir) | reintro. | 9/15/2004 | 2 veg. plants | --- |
| | | 9/30/2003 | 7 plants (4 repro., 3 veg.) | --- |
| | | 9/10/02 9/13/01 | 9 plants (all repro.) | Seeded (50K seeds) |
| | | 8/16/2000 | 0 plants | --- |
| | | 1999 | 1 veg. plant | Seeded (50K seeds) |
| | | | --- | Seeded (50K seeds) |

TABLE 12. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES MANAGED BY THE **USFWS** ALONG THE OREGON COAST. IAE CONDUCTED SURVEYS FROM 2009-2012.

| Site | natural or reintroduced | date surveyed | population size | Reintroduction history and other comments |
|-------------|--------------------------------|----------------------|-----------------------------------|--|
| Elk River | Intro | 9/25/2012 | 556 plants (384 repro., 172 veg.) | Seeded (100k seeds) |
| | | 10/4/2011 | 307 plants (105 repro., 202 veg.) | Seeded (100k seeds) |
| | | 9/21/2010 | 113 plants (86 repro, 27 veg.) | Seeded (100k seeds) |
| | | 9/20/2009 | 389 plants (353 repro., 36 veg.) | Seeded (100k seeds) |
| Crook Point | Intro | 9/21/2010 | 2 (1 repro., 1 veg.) | Seeded (50k seeds) |

TABLE 13. RESULTS OF SURVEYS FOR PINK SAND-VERBENA SITES ALONG THE OREGON COAST MANAGED BY VARIOUS LAND MANAGERS INCLUDING THE STATE PARKS DEPARTMENT. IAE CONDUCTED SURVEYS FROM 2000-2012. POPULATION DATA FOR YEARS PRIOR TO 2000 ARE FROM VARIOUS SOURCES.

| Site | natural or reintroduced | date surveyed | population size | Reintroduction history and other comments |
|--|-------------------------|---------------|-------------------|--|
| Charleston Beach (State and County Parks) | reintro. | 9/21/2010 | 0 plants | --- |
| | | 9/11/2002 | 0 plants | --- |
| | | 8/15/2000 | 0 plants | --- |
| | | 1996 | --- | Seeded and transplanted |
| Otter Point | natural | 9/13/2007 | 0 plants | 2000 was the first year since 1993 that no plants were observed at this site |
| | | 9/26/2006 | 0 plants | |
| Oregon Department of Parks and Recreation | | 9/15/2004 | 0 plants | --- |
| | | 9/30/2003 | 0 plants | |
| | | 9/10/2002 | 9 repro. plants | |
| | | 9/13/2001 | 3 repro. plants | |
| | | 8/16/2000 | 0 plants | |
| | | 1999 | 9 plants | |
| Heceta Beach | reintro. | 9/12/2001 | 0 plants | --- |
| | | 10/18/2000 | 0 plants | --- |
| | | 1995 | --- | Seeded (5K seeds) |
| N of Cape Blanco/ S of | natural | 9/12/2009 | 1 flowering plant | N42.8655 W124.53432 |

Blacklock pt.

| | | | | (identified by D. & D. Bilderback) |
|--|----------|------------|----------------------------------|--|
| Oregon Department of Parks and Recreation | | | | |
| Cape Blanco | natural | 9/26/2006 | 1 veg. plant | --- |
| Oregon Department of Parks and Recreation | | 9/15/2004 | 7 plants (3 repro., 4 veg.) | --- |
| | | 10/1/2003 | 0 plants | --- |
| | | 8/16/2000 | 2 repro., 1 N & 1 S of creek. | --- |
| | | 1999 | 1 plant | --- |
| | | 1984 | several plants | --- |
| Floras Lake | reintro. | 9/25/2012 | 67 plants (8 repro., 59 veg.) | --- |
| Oregon Department of Parks and Recreation/BL M | | 10/6/2009 | 0 plants | --- |
| | | 9/13/2007 | 0 plants | --- |
| | | 9/26/2006 | 65 plants (41 repro., 24 veg.) | --- |
| | | 10/4/2005 | 20 plants (all repro.) | --- |
| | | 9/14/2004 | 220 plants (81 repro., 139 veg.) | --- |
| | | 10/19/2000 | 10 plants (7 repro., 3 veg.) | Seeded (50K seeds) |
| | | 1996 | 7 plants | Seeded (5K seeds) |
| Hubbard Creek | reintro. | 9/14/2004 | 4 repro. plants | --- |
| Oregon Department of Parks and Recreation | | 10/1/2003 | 0 plants | --- |
| | | 9/11/2002 | 0 plants | --- |
| | | 8/15/2000 | 0 plants | --- |
| | | 1999 | 1 plant | --- |
| | | 1996 | --- | Seeded & transplanted |

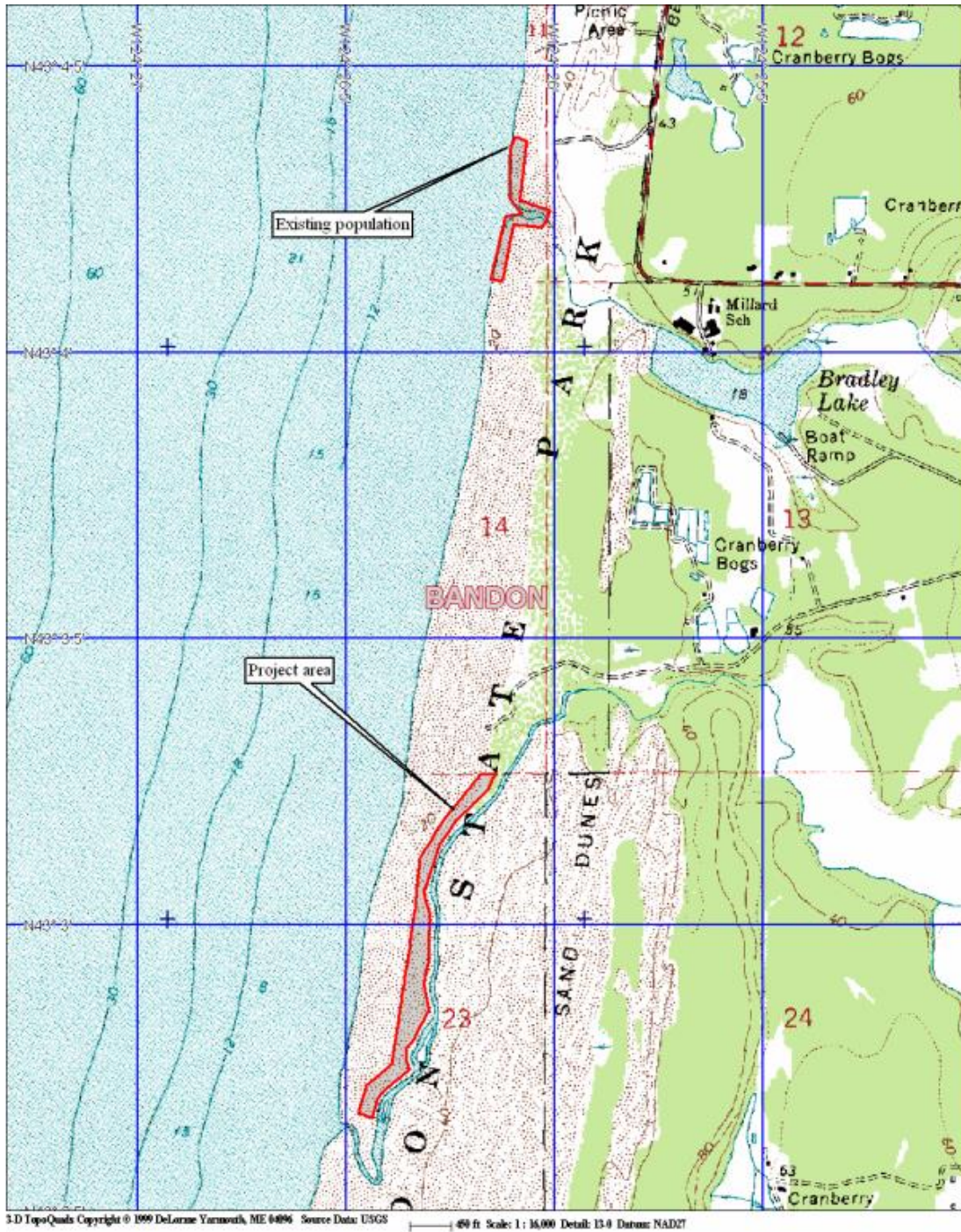
Abronia umbellata var. breviflora on the Oregon coast: Reintroduction and population monitoring

| | | 1995 | --- | Seeded & transplanted |
|---|---------------------|------------|--|--|
| Port Orford | natural & augmented | 10/2011 | 146 reproductive plants | --- |
| Oregon Department of Parks and Recreation | | 9/21/2010 | 136 reproductive plants | --- |
| | | 10/20/2009 | 269 plants (237 repro., 32 veg.) | --- |
| | | 10/16/2008 | 226 plants (only repro. counted) | --- |
| | | 9/13/2007 | 1,412 plants (846 repro., 566 veg.) | --- |
| | | 9/26/2006 | 660 plants (454 repro., 206 veg.) | --- |
| | | 10/4/2005 | 740 plants (392 repro., 348 veg.) | --- |
| | | 9/14/2004 | 909 plants (556 repro., 353 veg.) | --- |
| | | 9/30/2003 | 552 plants (159 repro. plants, 393 veg.) | --- |
| | | 9/10/2002 | 1,146 plants (480 repro. and 666 veg.) | --- |
| | | 9/13/2001 | 2,607 (1,467 repro. and 1,140 veg.) | --- |
| | | 2000 | 1,834 plants | --- |
| | | 1999 | 7,169 plants | --- |
| Winchuck River | natural | 9/10/2002 | 6 repro. plants | New site in 2000; N & S of creek mouth |
| Oregon Department of Parks and Recreation | | 8/16/2000 | 5 repro., 1 veg. | |
| Salmon River | reintro. | 9/22/2012 | 0 plants | --- |
| | | 9/26/2009 | 0 plants | --- |
| Camp Westwind | | 10/22/2005 | 92 plants (52 repro., 40 veg.) | --- |
| (Westwind Stewardship Group) | | 11/20/2004 | 1 repro. plant | --- |
| | | 10/24/2002 | 163 plants (129 repro., 34 veg.) | Seeded (50K seeds) |
| | | 9/10/2001 | 741 plants (488 repro. 253 veg.) | Seeded (40K seeds) |

APPENDIX III. MAPS OF SELECTED SITES- SEEDED OR MONITORED

Bandon Beach State Park

Project location map at Bandon Beach State Park. "Project area" refers to the beachgrass control.

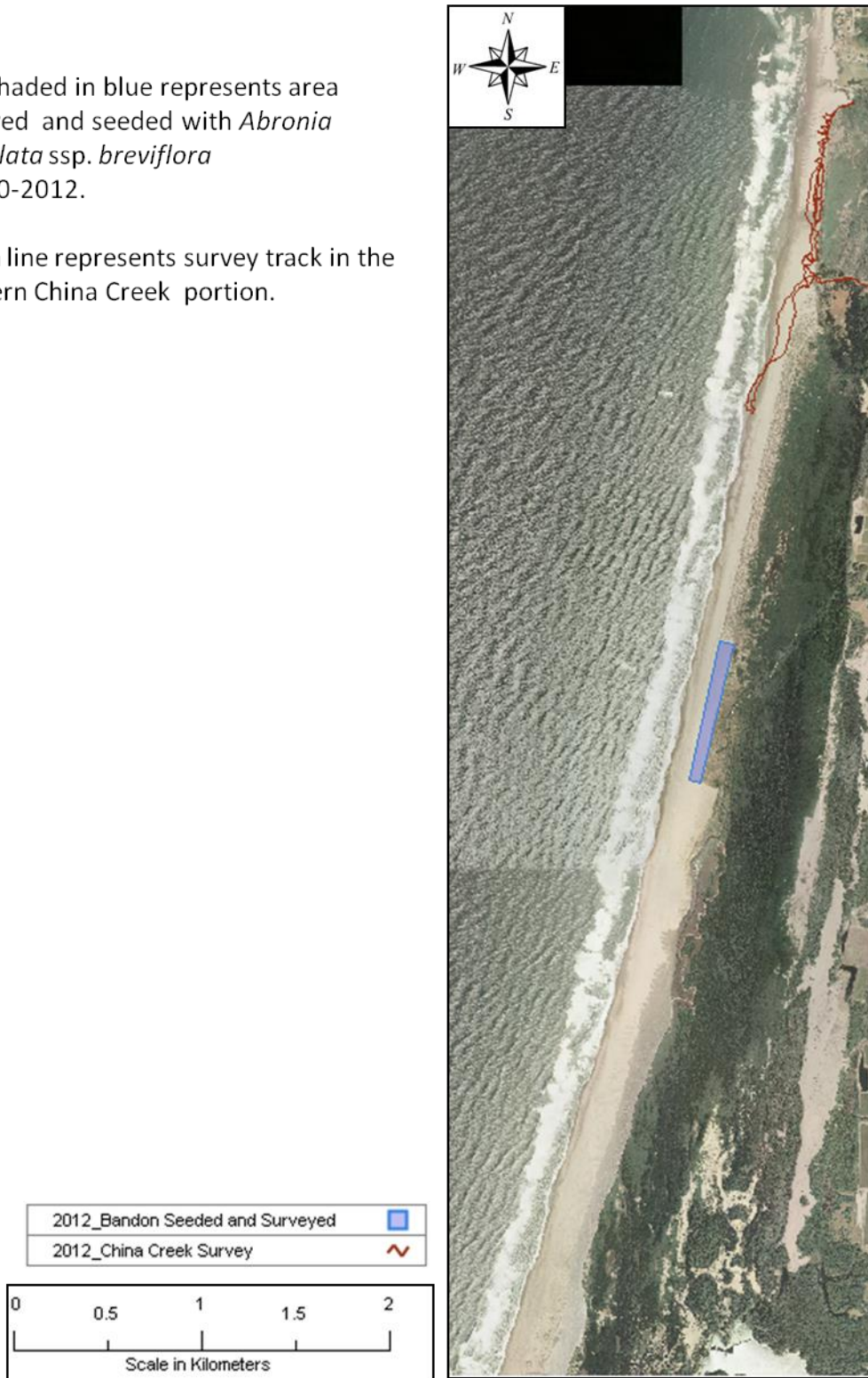


Bandon Beach and China Creek

Bandon Beach

Area shaded in blue represents area surveyed and seeded with *Abronia umbellata* ssp. *breviflora* in 2010-2012.

Brown line represents survey track in the northern China Creek portion.



China Creek

Brown line represents survey track in 2012.

Red squares represent *Abronia umbellata* ssp. *breviflora*, and *Abronia latifolia* found in the northern portion of the area



Bastendorff Beach



Elk River

Shaded area represents area seeded and surveyed in 2009-2012.



Floras Lake



New River



Overlook North and South



Port Orford

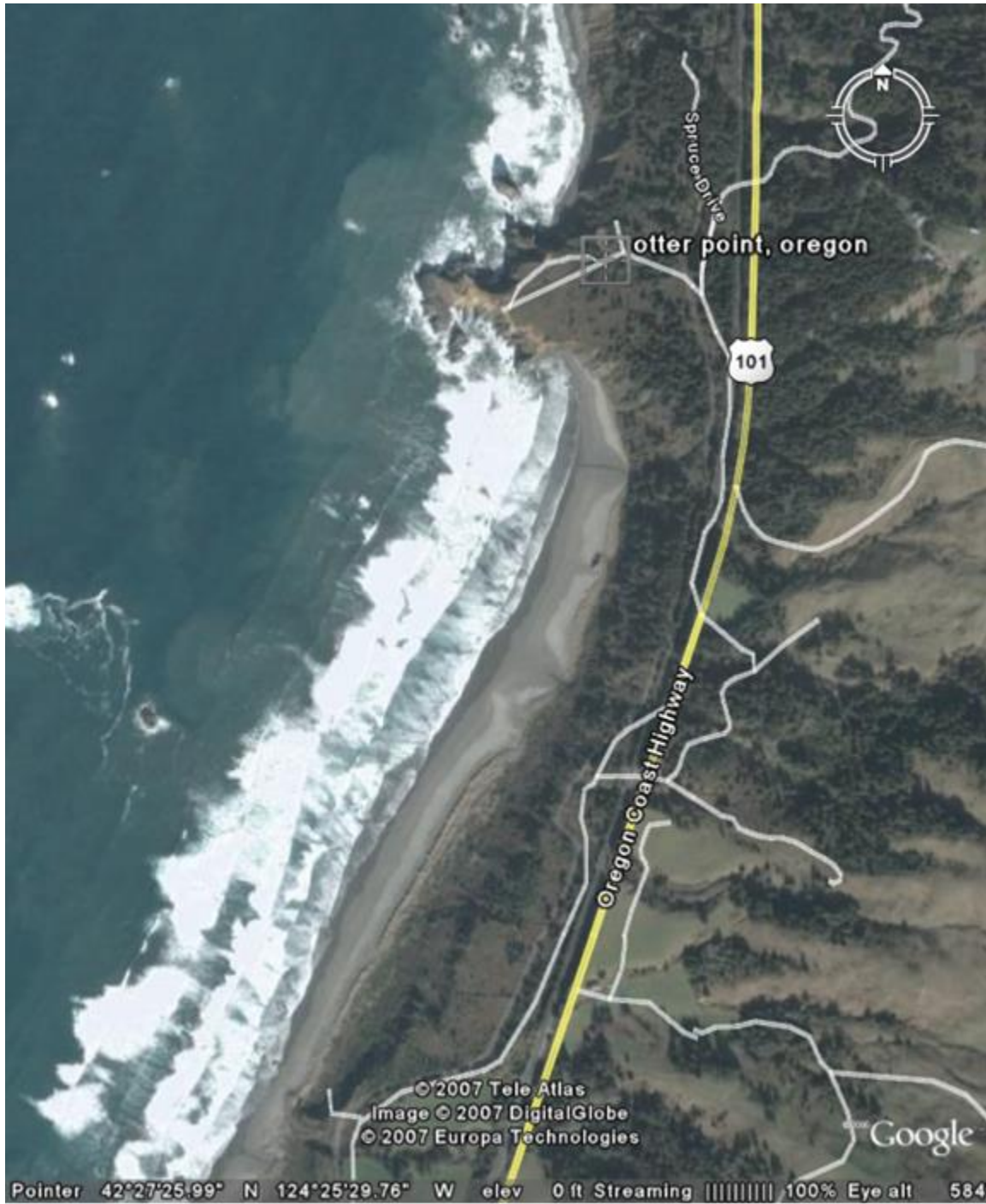


Ophir/Euchre Creek

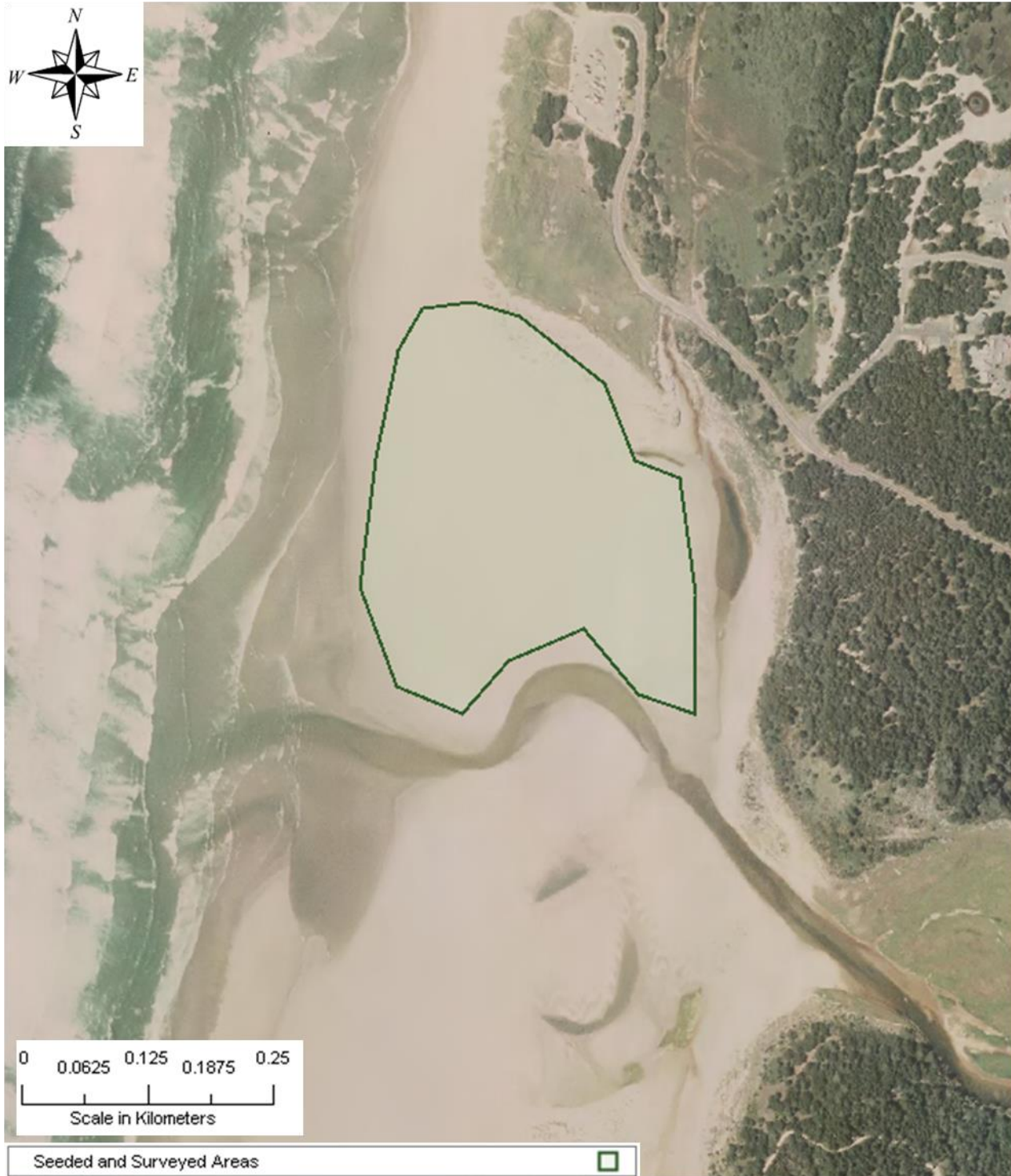
park on highway, walk down gravel road (ignoring no trespassing sign), knock on door of house on way to beach. a few years ago, Nancy Brian (BLM) talked to them and they were nice ... if not home, continue to do survey, but stop by house again on way back



Otter Point



Siltcoos



Tahkenitch



APPENDIX IV. POPULATION MONITORING AND SEED ADDITION AT OTHER SITES

BAKER BEACH

Seeding at Baker Beach has consistently had moderate success, resulting in a range from 12 plants (6 reproductive) in 2006 to 93 plants (37 reproductive) in 2004 (Table 10). We generally found plants south and east of the snowy plover habitat area in areas protected by larger dunes. In 2009, 6 plants were found (5 reproductive and 1 vegetative). In 2010, 2011, and 2012, no seeds were distributed at this site and it was not monitored.

BASTENDORFF BEACH

This site received both transplants (1995 and 1996) and seeding (most years between 1995 and 2005, Table 13). No plants were found until 2002, when 8 reproductive and 5 vegetative plants were counted. The population continued to increase to its maximum level in 2005 of 536 plants (410 reproductive). Seeding last occurred in 2005 and although small (between 2 and 11 plants), we have observed plants each year we have monitored, including nine plants (six reproductive) in 2008 and 2 plants (both reproductive) in 2010.



FIGURE 14. PINK SAND-VERBENA IN THE NORTH CENSUS AREA AT THE COOS BAY NORTH SPIT. PINK SAND-VERBENA TENDED TO BE FOUND ALONG THE RIDGES LEFT BY THE DISC HARROW. THIS PATTERN WAS ALSO NOTED AT THE OVERLOOK SITES IN 2009.

CAPE BLANCO

The natural population at Cape Blanco has been below seven individuals in the five surveys conducted since 1999.

DRIFTWOOD CREEK

Fifty thousand seeds were distributed at Driftwood Creek in 1998. No plants were counted in 1998, 2000, or 2001 surveys. In 2010 the site was revisited and no plants were found at the site.

EUCHRE CREEK

Although seeding resulted in only a few plants in 2000 and 2002, individuals continued to germinate in 2003 and 2004. We recommend that this site be resurveyed in 2011.

FLORAS LAKE

Direct seeding at Floras Lake in 1996 (5,000 seeds) and 2000 (50,000 seeds) resulted in only seven and 10 plants in each year (respectively). However, in 2004, 220 plants were observed growing in an area protected from wave action by a sandstone outcrop. We counted 65 plants in 2006. No plants were found in 2007 or 2009. The persistence of the Floras Lake population, despite low reintroduction effort, suggests that this habitat may be a good site for future seeding.

ONA BEACH

In 2000, two plants were counted at the mouth of Beaver Creek; this was the first time plants had been documented at this site. In 2001, no plants were found and no surveys have been completed since that time.

OTTER POINT

The wild population of pink sand-verbena at Otter Point has shown dramatic swings in size since 1993. From 1993-1996, the number of plants varied from 9 to 16, but in 1997 and 1998, the population rose to 177 and 136 plants, respectively. The population declined substantially after that, dropping to 0 in 2000 and rebounding to only 3 plants in 2001 and 2002. No plants were observed from 2003-2007 (the site was not surveyed in 2005; Figure 10). Re-colonization of the site after dropping to 0 plants in 2000 suggests that the population at Otter Point (and possibly others) can re-establish from a persistent seedbank. Monitoring should continue at this location, and if the species continues to be absent, the possibility of reintroducing the species should be evaluated.

PISTOL RIVER

Plant establishment at Pistol River State Park was extremely low. Eighty thousand seeds were distributed at the site in April 2008. In October 2008, only one vegetative plant was located. Although seeding pink sand-verbena in April has been successful in the past, there may not have been sufficient time for cold stratification in the weeks following seeding in 2008. This likely contributed to the low germination rate. In addition, a bench that had been seeded in April had eroded to beach level during the summer, significantly reducing the amount of pink sand-verbena habitat present at the site. In 2009, no plants were found at the site.

PORT ORFORD

The population at Port Orford is both natural and augmented. In 1999, over 7,000 plants were counted; since that time there has been a downward trend in yearly population numbers (Table 13). In 2007, the population size more than doubled compared to the previous year (1,412 plants, 846 reproductive). Of these, 168 plants (118 reproductive) appeared to be hybrids with yellow sand-verbena. In 2008, 226 reproductive plants were counted, 79 of which were potential hybrids. In 2009, 269 plants were counted, 237 reproductive and 32 vegetative. In 2010, 194 plants were counted, 58 of which appeared to be hybrids. In 2011 146 plants were counted at the site. This habitat is relatively well protected from ocean storms and has the potential to be quite large. Given that this is one of the few (partially) natural populations that remains on the Oregon coast, we strongly recommend renewed attempts to remove European beachgrass.

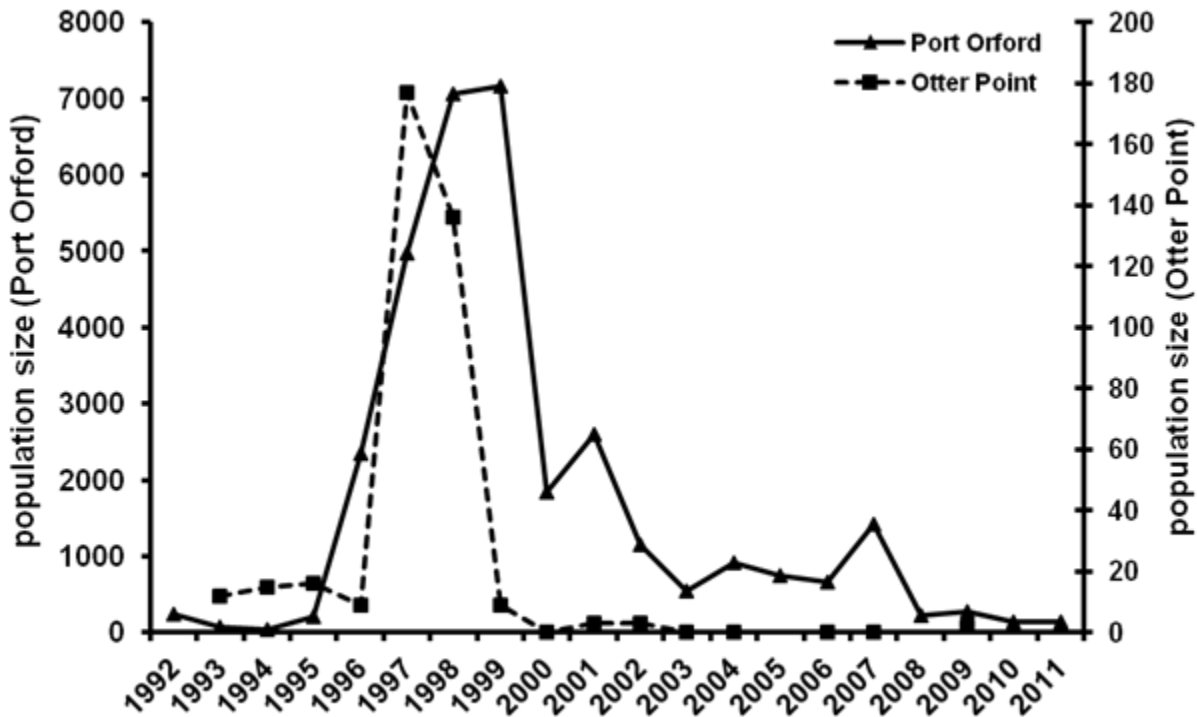


FIGURE 15. POPULATION TRENDS OF PINK SAND-VERBENA AT OTTER POINT, A NATURAL, UNMANIPULATED POPULATION AND PORT ORFORD, A NATURAL POPULATION THAT HAS RECEIVED INTENSIVE RESTORATION IN THE FORM OF AUGMENTATION (TRANSPLANTING), PARTIAL ELIMINATION OF BEACH GRASS BEHIND THE FOREDUNE, AND DISTURBANCE WITH MACHINERY (1992-1999). THERE ARE NO DATA FOR OTTER POINT IN 2005 OR 2008 TO PRESENT.

SALMON RIVER

Restoration seeding took place at Salmon River in 2001 and 2002. These efforts resulted in 741 and 163 total plants in 2001 and 2002, respectively. In 2005, 92 plants (52 reproductive) were present, despite no seeding that year. This site was not surveyed in 2006, 2007, or 2008. The recruitment of plants from the seedbank in 2005 suggests that this population could be maintained with management activities including beachgrass control and seeding.

SUTTON CREEK

Seeding at Sutton Creek had low success in two out of the three years it was seeded. In 2004, 150 plants (28 reproductive) established after a spring seeding. No plants were found at the site in 2005, 2006, or 2007 despite seeding in 2005 and 2006. This site appears to receive a relatively high level of disturbance from wind, wave action, flooding, and bed-movement by Sutton Creek. Due to the disturbance and the poor recruitment, we did not seed the site in 2007 and subsequently found no new plants.